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MEMOIR

OF

GENERAL SIR EDWARD CHARLES WHINYATES, K.C.B., K.H.

General Sir Edward Charles Whinyates, K.C.B., K.H., of the Royal Artillery, third son of Major Thomas Whinyates, of Abbotsleigh, in the county of Devon, and Catharine, daughter of Admiral Sir Thomas Frankland, 5th Baronet, of Thirkleby Park, Yorkshire, was born May 6th, 1782; he was educated at Mr Newcombe's school at Hackney, and entering the Royal Military Academy at Woolwich in 1796, was gazetted as 2nd lieutenant in the Royal Artillery on the 1st March 1798, at the age of fifteen years nine months.

England was at this period engaged in continental warfare, and it was not long before the young officer was summoned to the commencement of a career, which he pursued throughout a long life, with honour to himself, with credit to his regiment, and to the advantage of his country. Embarking in August 1799, he accompanied the expedition under Sir Ralph Abercrombie to the Helder, which resulted after two severe engagements, in the capture of the towns of Helder and Huysduinen, and the seizure of the Dutch fleet in the Texel. Joining afterwards the force under the Duke of York, he took part in the campaign in North Holland, and returned with the army to England in November of the same year, having received his promotion as 1st lieutenant the preceding month. In June 1801 his company, forming part of the secret expedition to Madeira under Sir William Clinton, assisted at the capture of that island, proceeding, on its evacuation after the Peace of Amiens, to Jamaica, whence after a service there of three years (the latter half of which period he was adjutant), he was ordered home, on promotion to the rank of 2nd captain in July 1805.

In July 1807, he was appointed adjutant to the artillery of the army, which, under Lord Cathcart, was employed in the attack on Copenhagen, and where he moreover commanded throughout the siege one of the principal batteries (the "Churchyard," consisting of eight 24-prs. and two howitzers); this battery was manned chiefly by the artillery of the King's German Legion, who were placed under his special orders, and Sir Thomas Bloomfield, commanding the artillery, expressed his opinion that the vigorous and well-directed fire therefrom, materially contributed to the success of that most important operation, the capture of the naval arsenal and the Danish fleet. Returning home in November, he was the following year appointed 2nd captain of Captain Lefebure's troop of Horse Artillery, and remained on home service until 1810.

In the February of that year, the troop embarked for the Peninsula at Portsmouth, in six vessels (part of a fleet of sixty sail), under convoy of the "Comus" and "Circe" frigates. Off the coast of Portugal, they were encountered by a violent storm, and the "Camilla" of 200 tons, having on board Captain Whinyates, 2 officers, and 36 horses, losing her masts, was in imminent danger of foundering, from which fate they were saved by the courage and admirable conduct of the gunners on board, to whose assistance too it was mainly due that they were at last enabled to make the harbour of Cork, after drifting for fourteen days almost a wreck in the Bay of Biscay. Refitting after a delay of some weeks, they again proceeded to sea, and disembarked after a prosperous voyage at Lisbon.

This untoward event had considerable influence on the subsequent fortunes of the troop, for, arriving thus in the Peninsula by detachments, it was thereby prevented from at once taking the field; its horses were distributed amongst the other troops to supply casualties occasioned in the preceding campaign, and not till several months had elapsed, was it again completed and enabled to participate in active field operations. This accounts too for Captain Whinyates' presence on the artillery staff at the battle of Busaco, which occurred during this interval, where he served as adjutant to Sir Haylet Framingham, commanding Royal Artillery, and with whom he continued until he rejoined his troop on its taking the field previous to the battle of Albuera.

At the latter hard fought and sanguinary victory, he commanded the half-troop which was attached to the cavalry on the right; it was here that some of the severest fighting took place, owing to the persistent efforts of Soult to turn the allied flank—efforts at one time nearly crowned with success; the half-troop was in the very thick of the *melée*, and the guns were repeatedly charged and ridden through by the French cavalry. The conduct of the troop was eulogized by Marshal Beresford in his despatch after the battle, and it was again honourably mentioned by General Lumley for its behaviour, when following the enemy after Albuera he engaged Latour-Maubourg's division of cavalry at Usagre, in which affair the French lost between 200 and 300 dragoons taken prisoners.

It was also at Aldea de Ponte in September 1811, at San Munoz, on the ford of Yeltes, 1812, when five out of the six guns were injured by the enemy's fire; at Ribera in Estremadura, July 24, 1812, and at many other affairs, being always in the advance and rear guards.

For his conduct in the brilliant attack and defeat of Lallemand's cavalry at Ribera, Captain Whinyates was mentioned in public despatches, and Major-General Long in his report dwells on "the rapidity of movement and precision of fire of the Horse Artillery, by which the enemy suffered considerably," adding, "I should be wanting in justice, if I omitted to express my admiration of the conduct of the artillery under the immediate orders of Captains Lefebure and Whinyates." But it was reserved for the French General Lallemand to pay a still higher compliment, and to render as grateful a tribute to an enemy as is to be found in any record; for, during a communication after the action under flag of truce, he made particular enquiries for the name of the officer who had commanded the guns near the river, and on learning it, sent the following message to Captain Whinyates:—"Tell that brave man," said he "that if it had not been for him I should have beaten your cavalry, but that meeting me in every movement with his fire he never would allow me to form for attack." Say, "that I shall mention his name in

orders as having been the cause of our defeat, and not your cavalry. Mind you say this to him. Promise me that you will give him this message."

Captain Whinyates was promoted to 1st captain in January 1813, which occasioned his return to England. During his service in the Peninsula as 2nd captain of Horse Artillery for 3½ years, owing to a peculiar regulation of the Board of Ordnance, no 2nd captain of artillery or engineers was eligible for brevet rank, and he received no promotion, although in command of the troop for a considerable time, during which it was repeatedly engaged with the enemy, and its conduct honourably mentioned in despatches several times; this regulation was rescinded soon after his leaving the army, and several of his contemporaries who remained with it, received the promotion by brevet, which, owing to the above regulation, he did not obtain until after the battle of Waterloo; his advancement in the service being thus much retarded, as well as his nomination to the higher classes of the Bath and Guelph.

His next service was in France and the Netherlands from April 1814 to January 1816; and with the Army of Occupation from August 1816 to November 1818. At Waterloo, he commanded the 2nd rocket troop, which was equipped with both guns and rockets, and in addition to having three horses shot under him, was struck by a round shot on the leg and severely wounded in the left arm at the close of the day, by a rifleman who had crept up quite close in the high standing corn. The troop which was in Picton's division, and in position on the ridge to the left of the road leading down to the farm of La Haye Sainte, had three of four officers severely wounded—Captains Whinyates and Dansey, and Lieut. Strangways (the fourth, Lieut. Wright, being struck by a musket ball), and 32 non-commissioned officers and men, with 49 troop horses killed and wounded. It fired the following ammunition:—

Solid shot 309, spherical case 236, common case 15; total 560, rockets 52.

For his services at Waterloo, Captain Whinyates was awarded a brevet majority, the medal for that action, and a permanent pension for wounds, and for the Peninsula the silver medal with clasps for Busaco and Albuera. He subsequently obtained a troop at the express desire of Lord Hill, in whose corps he had served, and joined Lord Lynedock in the Netherlands. His troop being reduced in 1816, he was appointed to a troop of drivers in the Army of Occupation, and losing it by reduction in that corps in 1818, was re-appointed to the first vacant troop of Horse Artillery by the Duke of Wellington.

This account of his war services cannot be more appropriately terminated, than by giving an extract from a letter written to him by Major-General Long on the 17th April 1816:—

> "I know of no officer who served under my command in the Peninsula war, or even in the corps commanded by the present Lord Hill, who has stronger claims upon my sense of justice, gallantry, and merit, than *yourself*.
>
> "I do, therefore, most unequivocally and conscientiously declare, that, during the whole and very considerable period of time that the troop of horse artillery commanded by the late Captain Lefebure and yourself acted under my orders and personal observation, I never witnessed more exemplary conduct in quarters, nor more distinguished zeal and gallantry in the field, than were uniformly shewn, and in several very trying

instances, by every officer serving in that troop, and most conspicuously so by yourself; and limiting even this, my opinion, to two occasions (though it would be a gross injustice to you to do so where so many others occurred), I should not hesitate, one moment, to assert that your brilliant conduct at Albuera, and San Munoz, alone, entitled you to a full participation in every honor and consideration, due to exemplary and distinguished services, which may have been bestowed upon your contemporaries.

"I have a right to make these assertions, not only because I witnessed your behaviour with admiration, but because it is the only species of remuneration in my power to render to those, who, whilst serving under my command, so ably and gallantly supported the military operations for which I was often and personally responsible."

Sir Edward was as successful in the performance of the routine duties of home service, and in maintaining by his zeal and attention, the high name which the Royal Artillery has ever held for regularity and discipline, as he had previously been in the more stirring scenes of camp life. Thus, on leaving Pontefract, the following gratifying resolution was forwarded to him:—

At a meeting of several of the Aldermen and principal inhabitants of Pontefract held at the Rotation Office, the 10th October, 1825.

Mr Alderman TRUEMAN, in the Chair.

RESOLVED:—

"That the thanks of this meeting be given to Majors Whinyates and Michell, and the officers, and to the non-commissioned officers and privates of the troop of Royal Horse Artillery lately quartered here, for their uniform regularity, discipline, and exemplary conduct observed by them during the whole of their stay, a period now of upwards of four years. And that they be assured that wherever their future destiny may lead them, they will carry along with them the sincere respect and the hearty good wishes of all classes of the inhabitants of this place for their welfare, prosperity, and happiness.

"That the chairman be desired to forward a copy of the foregoing resolution to Majors Whinyates and Michell, with a request that they will communicate it to the other parties to whom it refers.

"EDW. TRUEMAN, Chairman."

And again, in September 1830, on marching from Athlone, Sir Thomas Arbuthnot, the General Commanding, writes to the Adjutant-General, that "he feels himself called upon to make a special report concerning the exemplary conduct and soldier-like appearance of the troop during its stay in that garrison."

At the dissolution of Parliament in April 1831, his cousin Sir Robert Frankland proposed, "as he was so well known and so much respected at Thirsk," to bring him in for the borough; but this offer, though in many respects highly desirable, he declined as tending to an interruption of his military career, and to withdraw him from the profession which was ever foremost in his thoughts.

He became a regimental lieut.-colonel on 22nd July 1830, and was appointed to the Horse Artillery in November 1834, commanding the brigade at Head Quarters, Woolwich, until his removal in May 1840, consequent on his appointment to the command of the Royal Artillery in the Northern District. The latter he held for eleven years, together with that of the troops in the four northern counties, during the disturbances amongst the manufacturing classes in 1840 and the following year. He was promoted by general brevet on November 23, 1841, to a regimental colonelcy, and was re-appointed to the Horse Artillery on the 28th of the same month, by Sir George Murray, Master-General of the Ordnance, who wrote to him, stating that he had nominated him, "as marking his sense of his merits and services." On quitting the Northern District to succeed Major-General Lacy as Director-General of Artillery at Woolwich in March 1852, Lord Cathcart, the General in command, issued the order here quoted:—

"The Lieut.-General regrets exceedingly being deprived of the services of Colonel Whinyates, who has so long commanded the Royal Artillery in the northern district, with so much advantage to the service, and to the Lieut.-General's entire satisfaction in all respects.

"Being called upon however to assume the higher and more important duties of Director General of the Royal Artillery, the Lieut.-General takes this opportunity of congratulating Colonel Whinyates on his well merited preferment to that appointment."

That appointment however he held but for a few months, for in August 1852 he was made Commandant of the Garrison at Woolwich, retaining that command until July 1856, when he resigned in consequence of his promotion to Lieut.-General, on which occasion the following order was issued from the Horse Guards by command of the Field Marshal Commanding in Chief:—

ADJUTANT-GENERAL'S OFFICE, ROYAL ARTILLERY,
HORSE GUARDS,
21st June, 1856.

"Lieut.-General E. C. Whinyates having resigned his appointment of Commandant of the garrison of Woolwich, on being promoted to the rank of Lieut.-General, the Field Marshal commanding in Chief in accepting his resignation, takes this opportunity of thanking him for the manner in which he has invariably performed the important duties intrusted to him at Woolwich.

"Lieut.-General Whinyates began his career in 1779, by serving in Holland and at Copenhagen. In the Peninsula war, at Busaco and Albuera, his conduct was highly distinguished. His field services closed with the battle of Waterloo, where he was severely wounded. During the peace he has held the office of Director General of Artillery, and finally that of Commandant at Woolwich. In all these employments Lieut.-General Whinyates' exertions have redounded to his own credit and to the advantage of the service.

"By command of the Right Hon. Field Marshal Viscount Hardinge commanding in chief."

"H. D. ROSS,
Adjt.-Gen. of Artillery."

Colonel Whinyates became a Major-General in 1854, Colonel Commandant of a battalion in 1855, Lieut.-General in 1856, Colonel Commandant of Brigade R.H.A., July 22, 1864, and General on the 10th December of the same year. He was nominated Knight of the Guelphic Order for "distinguished military services" in 1823; Companion of the Bath September 27th 1831; and Knight Commander 18th May 1860. He married in 1827 Elizabeth, only daughter of Mr Samuel Crompton, of Wood End, North Riding of Yorkshire.

General Whinyates took a lively interest in the welfare of the Regimental Institution, and was a liberal benefactor to its funds. At the time of the occupation of the new building in 1852, he presented the Committee with £100 for the use of the Institution, and it is owing to this liberality that the Institution is now in possession of that magnificent work Gould's "Birds of Europe," and also of a firstrate Photographic Camera.

He died at Cheltenham on the 25th December 1865, in his 84th year, and the writer cannot more fitly terminate this short memoir, than by quoting the opinion of an officer who had the best possible opportunity of knowing Sir Edward's true character and guiding motives through a long life, which he thus summarizes:—

> "He was an excellent, gallant, and chivalrous soldier. His endeavour throughout a long life was to promote the honour and credit of the Royal Artillery; and his devotion to the welfare of the Horse Artillery was unbounded—no officer ever possessed it to a greater degree."

MEMOIR

OF

GENERAL SIR WILLIAM CATOR, K.C.B., ROYAL ARTILLERY.

William Cator was the second son of Joseph Cator, Esq. of Beckenham, Kent. He was born 14th April, 1785.

He was educated at Westminster, whence he joined the Royal Military Academy at Woolwich, which he entered as an East Indian Cadet, 13th June, 1800. He did not however join the Company's service, but received his first Commission in the Royal Regiment of Artillery, 7th May, 1803.

Soon after joining at Woolwich he was ordered to the Channel Islands, and was promoted to the rank of 1st Lieutenant while serving at Jersey, 12th September of the same year (1803).

He got his first appointment to the Horse Artillery in 1803, when he was posted to Major Charles Godfrey's Troop, with which he was quartered for some time in Dublin with the late Major Bean, 2nd Captain, Sir John Conroy, and Major Green as brother Subalterns, and many were the amusing anecdotes he told of those days. While he was quartered in Ireland, Cator had an opportunity of indulging in his early passion for field sports, and began to shew that aptitude for them which in later years was so exemplified by the manner in which, he at several different periods himself handled foxhounds.

He was promoted to the rank of 2nd Captain 1st May, 1809, and served in the Walcheren expedition which sailed for the Scheldt under the command of the Earl of Chatham in July of the same year; being present at the capture of Middleburg, and at the siege and destruction of Flushing. During that expedition he became very intimate with Lord Fitzroy Somerset, a friendship which terminated only with Lord Raglan's death.

On Cator's return to England in November of the same year, he was ordered to proceed with his company to join Lord Wellington's army in Portugal. The ship in which he sailed from Portsmouth was nearly lost during the passage of the Bay of Biscay.

On arriving at Lisbon, his destination was changed, and he was ordered to join the Brigade of Infantry under Major-General the Honorable William Stewart, and proceed to Cadiz, on which city Soult was advancing, the force arrived only just in time to save the city from falling into Soult's hands.

The head-quarters of the brigade were established on the Isla de Leon, and steps were immediately taken for fortifying the place.

Captain Cator was appointed Adjutant to the Artillery of the Brigade by Colonel Duncan, then in command, and was frequently mentioned by that officer in the most commendable manner to the Master-General of the Ordnance.

After some time he resigned the Adjutantcy owing to a misunderstanding with his Colonel, and fortunate was it for him he did so, as the officer who succeeded

to his duties, together with Colonel Duncan, both lost their lives shortly after, owing to the explosion of a powder mill.

Military operations becoming stagnant, the little army of the Isla employed itself in establishing such sports and pastimes as the nature of the place would permit of; indeed Captain Cator, went much further, for notwithstanding the circumscribed and marshy nature of the island, his favourite passion could not rest, and he managed to procure some hounds from England, and soon established a pack which he hunted himself.

These hounds were afterwards sent to Gibraltar, and there helped to form what was afterwards so well known as the "Calpe' Hunt."

The great difficulty of finding game however soon discovered itself, and Cator resorted to many expedients for making up the deficiency.

He imported foxes from Barbary; but this plan not succeeding, some savage Spanish dogs were procured, which when required for sport had their paws rubbed with anise-seed, and thus often afforded the members of the Hunt a good run of fifteen or twenty minutes, when reynard's representative was bagged for another day.

In the following August, however, soon after he had got his pack of hounds into form, Captain Cator was summoned to more active service, being ordered to proceed into Andalusia to purchase horses for the batteries at Cadiz. By great exertions and tact, he succeeded in procuring 100 horses and sent them into Gibraltar, whence they were shipped for Cadiz.

Without this seasonable supply the artillery would not have been able to take the field as it did, when orders were received for it to join the main army previous to the march on Torres Vedras.

Captain Cator accompanied the main army when it retired into Portugal, and was present during the masterly occupation of the celebrated lines of Torres Vedras on the 8th October, 1810. He was also engaged at Santorem later in the same year, after which he returned to Cadiz.

Major-General Stewart had meanwhile been relieved of the command of the brigade stationed there by Major-General Graham, whom Cator found was just the man to second his efforts for the encouragement of field sports. With the assistance of the latter racing was introduced; and by this and many other expedients Cator managed to draw together all classes, English and Spaniards in common amusements and friendships.

But this state of happiness, existing almost within sight of the enemy as it did, could not remain long undisturbed.

An opportunity offered itself, and Graham was not the man to lose it.

He immediatety set to work to devise a plan of operations for raising the siege, in conjunction with the Spanish Commander Don Manuel de la Peña, who had at his disposal some ten or twelve thousand men.

In February 1811, the whole of the British force, together with a portion of the Spaniards, embarked on board the English fleet, intending to effect a landing at Tarifa or Algesiras, and thus cut off Victor (who had succeeded Soult) from his base of operations, and whom they were to attack simultaneously with a Spanish force which was to advance from Cadiz by land.

On the march, the British force which did not consist of more than 4000 men and ten or twelve guns (and was called the reserve), owing partly to the difficult nature of the country, became separated from the Spaniards (to which force it was acting as a rear guard); and on the night of the 5th March, found itself occupying the heights of Barrosa. The men were about to refresh themselves after their long night's march, when they were suddenly attacked by the French. No time was lost in encountering the enemy. (Napier's History of the War represents Graham, "A daring old man, and of a ready temper for battle").

Ten guns immediately opened a terrific fire against Victor's column, which in less than two hours was in full retreat, leaving two generals with 400 prisoners, six guns, and a standard in the hands of the victors.

The enemy however had inflicted great loss upon the little English band, no less than 50 officers, and 1193 men being killed and wounded. Cator, who had a horse shot under him, was among the latter; and for his conduct throughout the action he was mentioned by General Graham in his despatches to Lord Wellington.

The Spaniards however not fulfilling their part of the movement, the whole force returned to Cadiz; and the expedition led to no result, save that of raising a very indignant feeling throughout England against the Spaniards on account of their alleged refusal to support our troops at Barrosa.

Captain Cator returned to Cadiz, with General Graham's troops after the battle of Barrosa, and remained there till the raising of the siege in 1812; when he received orders to take command of a battery, and march through Spain to Madrid there to join for the second time, the main army under Wellington.

Immediately on his arrival at head-quarters, Captain Cator was again selected by Lord Wellington, to undertake the task of proceeding into Andalusia, and endeavour to purchase with all dispatch 700 horses and 300 mules; telling him to appoint an artillery officer to assist him. Captain Cator selected Lieut. Francis Warde for this purpose, and proceeded to traverse the whole district of Andalusia, riding post horses, going from place to place by night, and riding through the neighbouring district by day in search of animals. He continued to do this for six successive days and nights; during which period he purchased 573 horses, and 248 mules, which were collected at Seville; and all reached head-quarters within thirteen days of Captain Cator's undertaking the duty. With his usual forethought he made arrangements for any further supply that might be required, which saved him another similar journey, for which he was destined on his return to head-quarters.

Lord Wellington was so manifestly satisfied with the manner in which Captain Cator had so efficiently executed his orders, that he mentioned him warmly in his despatches home; and at the same time wrote to the Master-General of the Ordnance, earnestly recommending Captain Cator for the earliest vacancy as 2nd Captain of Horse Artillery.

In this instance as on many occasions in after years, Captain Cator displayed that energy and determined resolution which so often enabled him to accomplish undertakings that to most other men would have appeared unattainable. At all times, whatever his employment, whether the pleasures of fox hunting, the toilsome duties of a campaign, or promoting the welfare of his friends; he ever entered into it with the same hearty energy and spirit.

Captain Cator was next engaged at Osma in 1813, in which battle he served in the Horse Artillery, having been appointed Acting 2nd Captain of Major Bull's Troop, Captain Norman Ramsay being in command during Major Bull's temporary absence in England.

He was engaged at Vittoria in the same troop, and the day following that battle, was placed in command owing to the misunderstanding which led to poor Norman Ramsay's arrest, and which has become matter of history.

Captain Cator continued in command of the troop during the pursuit of the French army, and with the covering army before St Sebastian, and served with it till the close of the war. At Tolosa, by the skilful manner in which he posted his guns, he drove a considerable portion of the enemy from the field; and was in consequence highly commended by Lord Lyndoch (General Graham) in his despatches to Lord Wellington. He was also engaged in the passage of the Bidassoa, August 1813, and afterwards against the attack on the same place, by the French, in the actions of the Nive and Nivelle (November 10),

and in the four days fighting in front of Bayonne; during which he again brought himself to the notice of his chief, General Hay, by the clever manner in which he dislodged (with only two guns) a portion of the enemy who had taken up a commanding position on a height, and was by him mentioned so favourably to the Duke, that the latter wrote home and recommended Cator for a Majority, which rank was bestowed on him "as a mark of Royal favour" on 12th April, 1814. Major Cator was engaged in the attack on Toulouse in April (Easter Sunday).

He was on several occasions mentioned in despatches by Sir Alexander Dickson and General Fisher.

He returned home at the conclusion of peace.

In March 1815, the year after he returned to England, he married the only daughter of Sir John Farnaby, Bart., of Wickham Court, Kent, by whom he had a family of three sons and four daughters.

Major Cator remained in the Horse Artillery, and in 1819 moved with his troop to Ringmer in Sussex, and remained in command of it till 1823, in consequence of his Captain, Colonel Webber Smith, being abroad.

During this period he again had an opportunity of displaying great ability in his favourite pastime. He established for the first time, and for the several successive seasons he was stationed at Ringmer, he had the entire control of a subscription pack of foxhounds, the present "South Down," in those days called "The East Sussex," which he for one or two seasons hunted himself.

In 1823 he exchanged with the late Colonel Charles Blachley, into Sir Hew Ross' the famed "Chesnut Troop" that colour, with which its past career of glory had always been associated, being still proudly retained, and remained at Ringmer in command, Sir Hew Ross having an appointment in the north. He was promoted to the rank of 1st Captain, 29th July, 1825, and appointed to command the same troop. In 1827 he moved with it to Sheffield, and was quartered there till 1831, when he marched to Athlone, having received his promotion as Brevet Lieut.-Colonel, 22nd July of the previous year (1830).

While at Athlone, Cator was selected by Sir Hussey Vivian, then Commander-in-Chief in Ireland, to take charge of a force of cavalry and infantry, which was ordered to proceed to Galway, previous to the borough and county elections, when great disturbances were anticipated.

On this occasion as on many others, Cator's well known courteous manner and good humour bore him successfully through the difficulties with which he had to contend. His arrangements were so well conceived, that no collision took place between the military and the mob; in consequence of which he received the thanks of the Government.

In 1833 he moved with his troop to Dublin, where he remained until ordered to Woolwich in 1835.

He gave up the command on promotion, 10th January, 1837, when he was posted to the 2nd Battalion.

In the same year, however, he was again fortunate enough, to be re-appointed to that brilliant branch of the Corps, the Royal Horse Artillery, with which he served at Woolwich till 1842, when the command of the S.W. or Limerick district of Ireland was given to him, and he retained it till 1847. He had been promoted to a full Colonelcy on 9th November, 1846, when he was attached to the 6th Battalion.

Colonel Cator had thus spent no less than 38 years of his career in the Horse Artillery, a period of which he ever retained the proudest and fondest recollections.

In October 1848 he proceeded to Gibraltar, where he was appointed to command the Royal Artillery with the rank of Colonel on the staff.

He returned to England in 1851, having received the appointment of Fire-master in the Royal Arsenal at Woolwich, which post he did not long retain, as he was appointed Director General of Artillery in August 1852.

At the commencement of the Crimean War in 1854, Lord Raglan was Master-General of the Ordnance. He had known Colonel Cator for many years, and entertained a high opinion of his clearness of intellect and great capacity; consequently when his Lordship was named to the chief command of the British Army in the field, he at once appointed Colonel Cator to command the Royal Artillery, and the rank of Brigadier-General was conferred upon him.

In March 1854, the several batteries intended for the East were rapidly being embarked and despatched to the Mediterranean, and General Cator in concert with the authorities at Woolwich, issued detailed instructions to the various Officers in command, as to the care and comfort of the men and horses on board ship; and also pointed out to them the necessity of so arranging the *matériel* and stores, that they should be ready for disembarkation in the face of an enemy, should such be required. The following is an extract of one of his orders issued at the time.

"The Brigadier-General has the greatest confidence in the zeal, intelligence, and activity of the Officers under his command, and only begs to remind them, particularly with regard to the junior part of the service, that they are about to proceed on a service where the eyes of their country will be upon them; he never can doubt their gallantry before the enemy; but this is only a small part of the duties they have to perform; they must give their incessant attention to the comfort and care of the men, the condition of the horses, and the safety and serviceable state of the ammunition.

"They will by a proper attention to these duties place themselves in a distinguished position, and by neglecting them forfeit their advantage."

During the month of May, the army with Lord Raglan and his staff arrived at Scutari in the Bosphorus, and after a short detention there, were re-embarked and proceeded to Varna, it being at the time supposed, that the several divisions, would at once advance to the relief of the Turks, then sorely pressed by the Russians at Silistria on the Danube.

General Cator's attention on arrival at Constantinople was immediately turned to the urgent necessity of providing means of land transport for the siege *matériel* and ammunition reserves. The transport of the army at that time depended on the Commissariat, but as their resources in this respect at the commencement of the war were quite inadequate, General Cator obtained the sanction of Lord Raglan to make his own arrangements, so far as related to *matériel* of war. Accordingly he sent officers to various parts of Turkey to purchase mules, ponies, and buffaloes, (Colonels Gambier, and Collingwood Dickson being among those selected for the purpose), and many hundred animals were soon collected at Varna, and were there organized and distributed to the divisions of the army. The result of his assiduous care in this matter, was, that when the army landed in the Crimea, almost its only means of transport consisted of about 900 pack animals which had been collected entirely under General Cator's directions; and these not only proved of great service in bringing up reserves of ammunition at the battles of the Alma and Inkermann, but afterwards during the winter of 1854, when the army before Sebastopol was in such suffering and want, they proved invaluable in assisting to bring up food and clothing; so that although General Cator had not the good fortune to land in the Crimea, his previous forethought and experience proved of essential service at a critical period.

The detention of the allied armies in the unhealthy neighbourhood of Varna during the summer of 1854 resulted in great sickness amongst the troops generally, and General Cator's health, which even at Scutari had shewn symptoms of failing, gradually gave way, and latterly he was unable to leave his quarters. Nevertheless his exertions never relaxed; he was in constant communication with Lord Raglan, and his endeavours were unceasing that the great branch of the Service, which he commanded, should in every way be prepared to take its part in the momentous expedition about to sail for the Crimea.

The force of artillery originally embarked from England for the East, was comparatively small, but as the war became developed many additional batteries were sent out, and the accumulation of battering trains, and of *matériel* at Varna became enormous; and it will readily be understood that the arrangements for the despatch of the whole for the Crimea ready for instant disembarkation required incessant care and great forethought.

It was in all such matters that General Cator proved himself so able a General of Artillery.

His arrangements were always so simple, his orders so clear, and his experience so great, that it can hardly be wondered that he enjoyed so completely the confidence of Lord Raglan, who frequently came to visit him when confined to his sick bed at Varna, and to consult him on the great difficulties of the expedition.

During the month of August, General Cator's health became worse and worse, and it was evident that he was quite unable to embark with the army; he repeatedly told Lord Raglan so, but he would not believe it, although at last he reluctantly allowed him to go to Therapia for the purpose of consulting the physician to the Embassy. He unhesitatingly gave it as his opinion that he must go home at once, to which Lord Raglan assented.

Lord Raglan frequently and warmly expressed his great regret, that the services of so able a commander should be lost to him at so critical a juncture. In a letter he wrote to General Cator, dated Aug. 17th, 1854, he says.—

"I cannot say how grieved I am at the prospect of my being deprived of the advantage of your assistance.

"Our long established friendship, my confidence in your judgment and desire to carry on your duties to my perfect satisfaction, and the extent to which you are looked up to by the officers of the Department, all combine to make me sensible, that on your departure I shall lose one whose services are invaluable, both to the public, and to myself.

"However, if it be evident that you cannot remain here, and that your return to England is absolutely necessary, I cannot object to it, and I will instruct the Adjutant-General to order a Medical Board to assemble for your examination."

And again, in a letter, dated Aug. 25, 1854, he says:—

"I have received your letter of the 22nd, but it reached me too late to enable me to answer it by the vessel that was sent down with the mail last night.

"I fear I can only view it as announcing your intended departure, if, which I can entertain no doubt of, the Medical Board shall report that they recommend your return to England. I consider your going a great loss to the service, and under the circumstances, a vast public inconvenience, and to me personally a heavy misfortune.

"It would have been a great comfort to me to have been assured of your able assistance, advice, and co-operation till the close of the War, but the separation is no fault of yours, and I must make up my mind to submit to it.

"I hope the voyage will restore your strength, and that when you get home you will be well enough to resume your former avocations, and attend to the many important matters which will come under your notice."

It will readily be conceived how great the disappointment must have been to the General himself, to watch transport after transport leaving Varna, and bearing away the batteries which he had hoped to command, and for which he had done so much to prepare for the field; and then to feel compelled to relinquish his appointment on their departure for active operations.

He had however the great consolation of feeling that he had done his duty, so long as the power remained, and also that of having arranged that his command should be given to his old friend and comrade Brigadier-General Fox Strangways, one so well worthy of it, and who fell gloriously at the head of his corps shortly afterwards at the great battle of Inkermann.

The following letter was written by the Duke of Newcastle to Lord Raglan, dated 18th August, 1854:—

"Your private letter of the 27th July, placed the services of Colonel Strangways in so prominent and favourable an aspect, that I could feel no hesitation in applying to Lord Hardinge to submit his name to the Queen for the local rank of Brigadier-General in Turkey.

"Your recommendation was sufficient, but if any further had been requisite, it would have been supplied by the strongly expressed wishes of General Cator, the valuable services of this meritorious officer entitle such a desire on his part to every consideration."

His Chief was indeed loth to part with him, as the following letter, which he (Lord Raglan) wrote at the time to General Cator's daughter shews, as clearly as it also exhibits, that kindly feeling and warm-heartedness for which that "Fine old English gentleman" was so remarkable. A man whom he had once made his friend, he never deserted or forgot. He had known Cator through a long life, and therefore these expressions of his feelings towards him bore the greater value. The following are the words of his letter:—"I part with your dear father with the greatest regret, but the doctors tell him that English air is necessary for the recovery of his strength, go therefore he must I feel; I have every hope, however, that by the time he gets home, you will have no reason to complain of his appearance, and that you will be quite comfortable about him. He leaves the army with the highest character for ability and efficiency; and there is not in the Artillery an Officer or man who does not look up to him with confidence for advice in any, the smallest as well as the greatest, difficulty. To me his departure is most painful; his long friendship, his good will, his cheerfulness, are invaluable to me, and I do not know how to reconcile myself to such a loss. Take care of him."

Also, a letter from the Duke of Newcastle to Lord Raglan, dated Sept. 15th, 1854:—

"I received your letter of the 28th ultimo, announcing General Cator's return to England on sick leave with very sincere regret.

"To the army under your command, and to yourself the loss of this officer's services is such as cannot easily be replaced—and in the great operations in which you are now engaged, it will, I fear, be severely felt.

"On his own account I am grieved, that after labouring so hard to organize and render efficient that part of the army under his command, he should be deprived, at the moment when active service has commenced, of the opportunity of acquiring increased distinction.

"You will already have been informed by a previous letter, that Colonel Strangways has been promoted to the rank of Brigadier-General. I trust he may prove worthy to succeed General Cator in his present very important command."

On his return home, General Cator resumed his duties as Director-General, and it was under his well-directed arrangements that all the extensive *matériel* and armaments for the several siege trains were organized and shipped in rapid succession for the siege of Sebastopol, and the army and navy kept supplied with munitions of war.

Again, Lord Raglan writing to General Cator, dated Oct. 8, 1854, says:—

"I have received your two letters and Mrs Morland's, and I am charmed to hear such good accounts of you. I hope and believe you will get quite well, and that soon; but I doubt the propriety of your returning to this country.

"You had no option when the Medical Board pronounced upon the necessity of your going home, the knowledge of this will always be a consolation to you; and you will besides ever have the comfort of feeling that you did much for us when with the army, and that you enjoyed the respect and confidence of all who were under your orders; who viewed your departure with the most sincere feelings of regret.

"I will say nothing of myself, for you know full well what reliance I have always placed in you.

"I send you the copy of a letter I have had from the Duke of Newcastle, in which such honourable mention is made of you, that it would not be just to withhold it from you."

The very onerous duty also devolved on him for some time, of reporting upon all new inventions and propositions having reference to implements of war; his clearness of mind, together with the striking power which he possessed of immediately mastering the salient and useful points of all propositions brought before him, were alike conspicuous to all who served under him.

On the 1st April, 1855, a committee was nominated to assist him in this portion of his duty. An enormous mass of crude ideas was brought before this committee, and it was generally believed that, under few other men as chairman could so great an amount of business have been so successfully accomplished.

General Cator's urbanity and kindly bearing to all who came before him, under any circumstances, was most pleasing.

On the 5th July, 1855, he was appointed a Companion of the Bath, and on the 1st April next year, received the pension for distinguished service.

He for some time acted as President of the Committee on machinery which directed the establishment of the Enfield factory for small arms, as well as the great improvements that were introduced in the machinery throughout the different departments of the Royal Arsenal.

During the period of six and a half years through which General Cator discharged the duties of Director-General of Artillery, the armament of the empire may be said to have entered on an entirely new era. His position was thus at that time of the most important character; as embracing not only the maintenance in efficiency of the extensive armaments of the forts and batteries of our Home and Colonial defences, but also the arduous duties of drawing out and reporting upon plans for the erection of numerous fortifications. For he was frequently employed in conjunction with military and naval officers, in visiting different parts of the kingdom, with a view to the better arming of salient positions of defence.

In fulfilling these and other collateral duties, much correspondence was entered into with the Master-General and Board of Ordnance, and latterly with the Secretaries of State for War. In fact, the work was so excessive, that General Cator's health again gave way under it, and in September 1858, he begged to be relieved of his duties.

He was persuaded however to continue in his position till the end of the year; but in December he was compelled to send in his formal resignation; stating that his health would admit of no further delay in its acceptance.

Thus with the fall of 1858, General Cator's active career closed; and he could well retire to his life of repose, with the conviction that he had performed services for his Corps and Country of which he might justly be proud.

Indeed, the Secretary of State for War, General Peel, wrote him a letter expressing in flattering terms his acknowledgments of General Cator's services, and of which the following is an extract:—

"In thus accepting your resignation, I desire to express to you my thanks, and the thanks of Her Majesty's Government, for the zeal and attention you have displayed in the discharge of your duties, and my regret at losing the assistance of an officer of your large and distinguished services."

On the 25th September, 1859, he was promoted to the rank of Lieut.-General; and on the 1st April, 1860, was appointed Colonel Commandant of the 15th Battalion.

In appreciation of his general services he was nominated a Knight-Commander of the Bath, in 1865; succeeded General Sir Edward Whinyates as Colonel Commandant of the "B" Brigade, Royal Horse Artillery, in December of the same year; and was promoted to the rank of General on 5th April, 1866.

For the last year, Sir William Cator had been in a very uncertain state of health, till on the 11th May, 1866, he succumbed to the never failing influence of Time, and died at the ripe old age of 81, leaving in his last message of affectionate remembrance to all his old surviving friends, an example of the amiable qualities, he had possessed, through a long and useful life.

One striking characteristic of his life must not be omitted in this short sketch of it.

For very many years, if not throughout the whole of it, Sir William Cator ever took as his unerring guide, the unfailing word of God. By night when disturbed and restless, and thus deprived of sleep as well as by day, did this good man familiarize himself with its contents; a fact that bore record of its fruits in the peaceful and happy nature of his death, and one that by being recorded here may possibly bear fruit hereafter, inasmuch as it tends to prove beyond a doubt, that a

zealous performance of earthly duties, a genial and sociable disposition, a warm and loving heart, are not only compatible with, but raise materially the character of the man who gives his life to God.

Should any young soldier cast his eyes over this short sketch of a soldier's life, he will learn from it that the warm and genial friend, the ardent sportsman, and the zealous soldier was throughout his long and honourable career, an humble follower of his Redeemer, and a devoted servant of his God.

Let the young reader lay this well to heart, and bear in mind that respected and beloved through life, honoured and lamented in death, so lived, so died, this gallant soldier, and excellent good man.

ANCIENT CANNON IN EUROPE.

PART II.

FROM A.D. 1351 TO A.D. 1400.

BY

LIEUT. HENRY BRACKENBURY, R.A., F.S.A.

ASSISTANT INSTRUCTOR IN ARTILLERY, ROYAL MILITARY ACADEMY.

IN a former paper[1] we traced the history of cannon as far as the close of the first half of the fourteenth century, up to which period trustworthy evidence of their employment was comparatively rare. We now enter upon a time, when, in every European nation, the great power of gunpowder began to leave its mark on the systems of warfare, and to bring about such changes, that almost every chronicler has some tale to tell of the wondrous effects of cannon.

During the first portion of the half century of which it is proposed to treat in this paper, the cannon in use throughout Europe were but little changed from those already discussed; but, towards the close of the fourteenth century, a great advance was made in the application of artillery, and we obtain evidence of cannon throwing balls heavier than those fired from any gun now in our service, and of far greater calibre than any piece which we now employ.

This great stride in the manufacture of cannon seems to have been made by most of the nations of the west of Europe at about the same time; but to mark more accurately the progress of various countries, we will deal separately with the artillery of France, England, Belgium, and Italy; selecting these nations as representing the chief actors of the fourteenth century in the great European theatre of war.[2]

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[1] Vide Vol. IV. p. 287.

[2] Germany, though doubtless possessing many interesting records of the early history of cannon, must be left without notice. To search through the entire field of German historical literature in hopes of finding some stray reference which might lead to information from contemporary sources, would be a labour beyond the author's power; and the book from which he had hoped to derive assistance affords none.

Herr Moritz Meyer's *Handbuch der Technologie für Artillerie Offizieren*, which has been generally accepted in Germany as the text book for the early history of cannon, and which in its French form

And first we will speak of France, where we are provided, by the research of the Emperor Napoleon III, with a considerable series of those most valuable of all contemporary documents, bills and accounts; which enter, far more minutely than any chronicle or history, into the materials used for and the method of manufacture of the cannon of this early period, with their stores and ammunition.

The accounts of Thomas Dautresche, receiver for the town of Laon, during the years 1356-7-8, furnish interesting information, by which we can estimate the size of some cannon manufactured at Laon during these years; they give also in detail the ammunition used with them. A long extract from these accounts is published by the Emperor Napoleon,[1] from which we select the following items :—

"Jehan de Rouzis made for the city 42 cannon, 1350 iron heads for 'garros,' for which he received (12 May) 115 écus.[2]

A 'grant canon à queue' was bought from Colart le Chandellier for 3 écus.

600 'garros' for cannon were winged with brass (empenes d' airain) for 32*s.* per 100.

Live sulphur and saltpetre to prove 43 cannon were bought from an 'espicier' for 2 écus.

12 lb. saltpetre cost 3 écus, 4 lb. for 1 écu.

Blocks of oak to make 'garrot à canons' cost $2\frac{1}{2}$ écus.

56 lb. saltpetre bought at a price of 4 lb. for 1 écu.

Wages to an 'artilleur,' 1 écu for three days, 12 days, 4 écus.

Technologie des armes à feu has been largely received in Europe as a standard work of reference, even by so distinguished an author as General Piobert, contains a series of assertions and assumptions unsupported by any evidence, or even by references, and in some cases carrying on their faces the stamp of improbability. It is therefore, as regards that portion which relates to the archæology of cannon, utterly worthless to the student or antiquary.

The author avails himself of this opportunity to protest against the pernicious habit of making statements, purporting to contain historical facts, without giving in every instance the source from which the statements are derived. The conscientious historian or antiquary will at once discard such books as worthless; but there will always be found a large number of bookmakers, who will accept these statements, and perpetuate them, though they may teem with error.

An instance of the necessity of tracing to its source every historical assertion, and of the consequent necessity of indicating where that source is, may here be given. Mr Sharon Turner, in his admirable History of England during the Middle Ages, states in a note (Vol. III. p. 490) that an account of the expenditure of the Ordnance Office in the Tower during the reign of Edw. III. shews a *maker of gun stones*, and *two gun founders*. He gives as his authority a work called Bree's Cursory Sketch, which refers the statement to Harleian MS. 5166. On consulting this MS. the author at once discovered that the writing was not of the 14th century; and, on referring to the authorities of the MS. Department, the MS. was pronounced to be of the 17th century, and the details to be, not of the household of Edward III, but of that of Queen Elizabeth.

Mr Turner had omitted to test the MS. for himself, or he would doubtless have at once discovered Mr Bree's mistake. But he gave his authority. Had he neglected this, or merely said these facts appeared from a MS. in the British Museum, it is possible that the author, trusting to the accuracy of so learned a man, might have reproduced his statement, and perpetuated a grave error in the history of cannon. This is but one instance out of scores of statements which the author has traced to their fountain head, and found to be erroneous.

[1] Etudes sur le passé et l'avenir de l'artillerie, Tom. III. pp. 88–90.

[2] The écu was equal to 13s. 4d., not 14s. 4d., as erroneously copied in the Etudes. This is evident from the fourth item of the account as it there stands.

Removal of 43 cannon (probably the 42 and the great cannon above named) beyond St Marcel for proof, and taking them back; and for the removal of 12 and returning them on a former occasion, 1 écu.

Charcoal ('charbon') for proving these cannon, 16*d.*

Timber ('mairien') and planks of white wood, on which the cannon were mounted, cost 13½ écus.

4 lb. ointment and ½ lb. wax given to the 'artilleurs' for their work, and to grease the espringales, ½ écu.

Strong planks for the sides ('oreilles') and uprights ('montans') of the cannon, 31*s.* 5*d.*

100 'garros' winged in three places for cannon 2¼ écus.

1358.

500 'garros à canons,' 5 écus.

Item, à Francois le serrurier pour IX canons sur III pies ferez et enchier denches et de platines par chascun I obole d'or valent III oboles d'or.

Item, pour XXI canons ferez et enchier chascun par lui denche et de platines et coustent les trois canons I escut valent VII escus pour tous ces canons enferer IX escus I quart.

29 lb. sulphur for powder for cannon, 5½ écus.

Charcoal, 16*s.*

Beaters to beat the powder, 20*s.*

A great leathern sack and three lesser ones to hold the powder, 12*s.*

Four dozen little leathern sacks to distribute the powder, 1 obole d'or, 2*s.*

400 'garros' winged, half for cannon, half for espringales, 2¼ écus per 100, 9 écus.

Removal of the said artillery, 10*s.*"

Then follow other entries relating to espringales.

From this series of accounts we learn that the corporation of Laon, already possessing at least twelve cannon, caused to be made at one time forty-three others, one of which is described as a great "canon à queue." These forty-three cannon were then removed to a suburb of the town for proof, and afterwards taken back into the town, and mounted on frames composed of timber and planks of white wood. To their form, or that of the frames on which they were placed, we have no clue; and we can only judge of their size by comparing their price with the wages of a skilled mechanic, as given in the same account, and by the quantity of powder used at their proof. Applying the first test, we find that the great "canon à queue" cost three écus (two pounds), while the *artilleur* received daily one-third of an écu; so that the value of this large cannon was only equal to nine days wages of a skilled artilleryman, or, according to another item, between twenty-two and twenty-three days wages of a common labourer.

The sulphur and saltpetre for their proof cost two écus, the charcoal 16*d.* The price of saltpetre was ¼ écu per lb., and that of sulphur rather more than ⅕ écu per lb. If the powder contained twice or three times as much saltpetre as sulphur, (and in the previous half century the former proportion of saltpetre was rarely exceeded,) this sum of money would have sufficed for about 6 lb. saltpetre and 2½ lb. sulphur. Add to this some 2 lb. charcoal, and from 10 lb. to 11 lb. powder is obtained for the proof of forty-three cannon, or about 4 oz. of powder for each cannon. The proof charge was probably rather a large one, or else at least two discharges would be required as a safe test for each cannon; hence we deduce that 2 oz. or 3 oz. was the service charge of

powder for these guns, which, estimating the projectile at ten times the weight of the powder,[1] would not admit of any projectile heavier than about 2 lb.

Again, the whole cost of the removal of the forty-three cannon to proof, and restoring them, as well as removing twelve cannon on a former occasion, was only equal to the wages of three artillerymen for one day.

Under date of the year 1358 we find this curious item "to a blacksmith *pour* IX *canons sur* III *pies ferez et enchier denches et de platines par chascun* I *obole d'or valent* III *oboles d'or,*" and next in order "*pour* XXI, *canons ferez et enchier chascun par lui denche et de platines, et coustent les trois canons* I *escut valent* VII *escus pour tous ces canons enferer.*" These items are difficult of explanation. Napoleon says[2] "on voit dans ces comptes 24 canons placés sur trépieds et attachés par des ferrures." By this he appears to mean that the cannon were placed on tripods; but the more accurate translation of the first item seems to be, "for nine cannon on three beds," i.e. three on one stand or bed. This is the only way by which the entry "par chascun I obole d'or, valent III oboles d'or," can be explained. In thus translating *pied* as the stand or bed of the cannon, we are supported by several instances of that application of the word occurring in Christine de Pisan, one of which is quoted in the second volume of the Etudes,[3] and by the occurrence of the word, evidently bearing this meaning, in the account of the great cannon made at Caen in 1375.

The "enches[4] et platines[5]" most probably signify vents and vent covers: and the drilling the former, and making and attaching the latter, would be legitimate work for a smith.

The extremely high price of powder is well exemplified by these accounts, ten pounds of it costing more than a great cannon. It was kept in large leathern sacks, and transferred to smaller ones for distribution. Its manufacture evidently included the process of beating, by which means the ingredients were doubtless reduced to a state of fine powder.

The projectiles used were "garros" or cannon-arrows, and appear to have been of different prices, and to have served for espringales if necessary. Their shafts were of oak; they were headed with iron, and winged with brass, the most expensive arrows being winged upon three sides.

Unfortunately we have here no means of judging from these details of the form of the supports or beds of these cannon; but in a future part of this work, where it is proposed to engrave several forms of supports from MSS. of the 15th century, this question will be again discussed.

These accounts of Laon confirm the inferences drawn from the documents cited in dealing with the history of cannon in the first half of the fourteenth century, and strengthen the opinion given that the two large guns mentioned in the accounts of Edward III. of England, in 1346, were but small pieces,

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[1] This proportion was chosen in a former case, vide Vol. IV. p. 292.

[2] Etudes, &c., Vol. III. p. 88.

[3] Ibid. pp. 64 and 69.

[4] Enche—a canal, gutter, channel. Vide Roquefort, Glossaire de la langue Romane.

[5] Of the application of the "plataine" to the vent of the cannon, a curious instance occurs later, vide p. 9.

and hence, by deduction, that the guns not mentioned as being large must have been very diminutive. Further corroboration of this argument will be found further on.

Under date of 24th February, 1357, we read in the archives of the town of Chartres,[1]

"A Guillaume le Fevre du Cloistre pour le reste qui lui estoit deu des canons que il a livrez à la ville et pour faire ferrure d'espingalles artillerie et martinez 12*l.* 10*s.*"

The town of Chartres, thus paying for cannon and other warlike engines, was no loser by its purchase; for Froissart tells us[2] how, eight years later, the bourgeoisie of Chartres lent their engines to the Duke of Burgundy, by which means he took the castle of Camerolles, and gave it to them "pour le salaire de leurs engins," and because they asked especially for it, as its owners had always been dangerous and troublesome neighbours.

In 1358, the famous Stephen Marcel caused his adherents to remove some cannon which were in the Louvre at Paris to the Hotel de Ville, and elsewhere. These cannon were crown property, as we learn from the fact that Jehan de Lyon, the officer entrusted with the charge of them, fled to Metz to the Dauphin, from whom he obtained a release for himself and his heirs.[3]

On the 17th June, 1359, a receipt was given by the "général lieutenant de monsieur le maistre des arballestriers du roy," for "deux grans canons garniz de poudre et de charbon et de plommées" for the defence of Melun[4]; and on the following 15th October, the "artilleur du roy, en son chastel de Meleun" gives a receipt for "cinquante six plommées rondes pour canons; *item* trente deux autres plommées; douze livres de plon pesant, et vint et trois livres de poudre pour canons.[5]

The archives of Lille[6] contain an entry of payment to a messenger in the following year (1360), who was despatched to Bruges to buy "quariaux salpetre et souffre pour la ville;" and it appears that he there purchased 5100 arrows, 30 lb. saltpetre, and 12 lb. of sulphur.

Again in 1368[7] the citizens of Lille purchased at Tournay 23 cannon, for 23*l.* 6*s.* These were fixed by iron fastenings into wooden beds. At the same time there were purchased "CXII plommées de canon pesans CXXVII liv. et demie."

In all these instances we have only to compare the quantity of powder with the number of projectiles, or, as in the last case, to notice the weight of the projectiles themselves; and we cannot fail to be convinced that the

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[1] Etudes, &c., Vol. III. p. 91.

[2] Froissart, ed. Buchon, Vol. I. Part 2, ch. 278, p. 486.

[3] Etudes, &c., Vol. III. p. 91.

[4] B. R. original parchemin, parmi les titres scellés de Clairambault, Vol. IX. fol. 483.

[5] B. R. orig. parch. au cabinet des titres de la bibliothèque royale.

[6] Etudes, &c., Vol. III. p. 93. At this time Lille belonged to France, and was not reconveyed to the Belgian provinces till 1383, when Philip the Hardy, by virtue of his marriage with Margaret, heiress of Louis of Nevers, became Count of Flanders, and received Lille as a gift from his brother, Charles V.

[7] Ibid, p. 94.

cannon for which all these stores were provided, were still but small pieces, even when designated as great cannon.

A somewhat larger proportion of powder appears to have been allotted to four "great cannon," which were intended to form part of the armament of Harfleur in 1368.

According to Ducange[1] there appears "in computo auxiliorum coactorum pro liberatione Joannis Regis Franc. ann. 1368, in camera computor. Paris, 'Guillaume l'Escuier maistre des canons du roy, que icelui seigneur lui a ordonné estre baille pour querir cent livres d'estoffe à faire poudre pour quatre grans canons qu'il doit faire pour mettre en la garnison de Harefleur.'" But this quantity of 25 lb. powder for each cannon leaves but a small portion for each discharge, if we remember that it was intended as garrison ammunition, and so might at any time be required to last throughout a siege; and the duration of the sieges of those days frequently extended to several months.[2]

An extract from the register of accounts of the town of Arras furnishes the details of the stores provided for the defence of the various gates of the town in 1369. These gates appear to have been armed with several cannon, each of which was supplied with twelve "garros" and 2½ lb. of powder, about 3⅓ oz. for each charge. A hammer, a pair of bellows and a rammer, called "cache" or "poussoir" were the stores provided for the cannon. There were two cannon noted as small; but as 3 lb. of powder, and only 12 arrows were supplied for the two, the charge allowed for them appears to have been rather larger than that for the cannon not distinguished as small. This rather long document is printed entire in the Etudes;[3] one extract from it will be sufficient here, all the items being almost exactly alike, the names of the "connestables" and the gates being of course changed.

"Item à Willaume de Nauve connestable, pour ledite porte de Ronville: I canon, XII garros, I martel, I soufflet, I poussoir, I bannière en austée, IC de quarrelz à I pied, IIII pignonchiaulx, I falot, II livres et demie de pourre et un quarteron de tourtiaulx."

An order from Louis, duke of Anjou, to the treasurer of wars, dated 15th July, 1370, for the payment of money to "Jehan Beneger, maistre de l'artillerie du roy," specifies the following military stores amongst others as those to be bought with this money: "quatre canons du pris de doze franx; IIIC cavilhes, du pris de III franx; XV livres de poudre, pour les canons, du pris de V franx; IIIC plombades du pris de VIII franx; IIII buffets et IIII payrolets, pour le service des canons du pris de III franx."[4]

These cannon only cost 3 francs apiece; and 15 lb. of powder only permits of one-twentieth of a pound being used with each of the 300 leaden projectiles. They were apparently of the same type of breech loaders as those

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[1] Gloss. sub voce Canones.

[2] As for instance, the siege of Calais by Edward III. 1347-8, which lasted more than a year, or that of Rheims by the same monarch, lasting six months, or that of Ventadour by the duc de Berry, 1387, lasting a year.

[3] Appendix, Vol IV. p. xiv.

[4] B. R. Clairamb., titres scellés, Vol. 46, intitulé: Amiraux de France, de Bretagne, Généraux des galères, fol. 169.

noticed at an earlier date, requiring a new pin or wedge (cheville) after each discharge. A pair of bellows (buffet) and a charcoal pan (payrolet) were provided for each cannon to heat the firing-irons.

Cannon of small calibre, throwing arrows, are again mentioned in a receipt bearing date the 29th December, 1371, given by "Jehan de Lions, sergent d'armes du roy et maistre de ses artilleries."[1]

But it is needless to multiply instances of the employment or purchase of cannon of the same nature throughout the kingdom of France, propelling arrows or leaden shot. As yet we have met with no cannon of large size, nor with any other projectile in France than the arrow or leaden bullet.[2]

In 1374, however, we find new projectiles employed in France, and the cannon from which they are to be thrown are considerably larger than any which have yet apppeared.

On the 1st November, 1374, Jean de Vienne, admiral of France, and the king's lieutenant in Lower Normandy, engaged at monthly wages of 15 gold francs one Girart du Figac, a "canonnier," to make certain large cannon throwing stones, and to fire them as often as might be required at the siege of St Sauveur le Vicomte. For these purposes stores of iron, steel, wood charcoal, a forge and bellows were required.

The original document from which this information is obtained is here extracted from the Etudes.[3] It is as follows:

"Jehan de Vienne, seigneur de Roulans, admiral de France et lieutenant du roy nostre sire ou païs de la basse Normandie, à nostre bien amé Nicolas le Prestel, receveur au diocèse de Constance des aides ordennées pour le fait de la guerre, salut. Nous avons retenu et retenons par ces présentes pour servir le roy nostre seigneur en nostre compagnie ès bastides de devant St Sauveur le Vicomte, Gerart de Fyugahc, canonnier, pour faire faire certains gros canons getans pierres et en faire geter toutesfoiz que besoing en sera; et lui avons ordonné qu'il ait et preigne de gaiges, pour chascun mois, la somme de quinze frans d'or. Si vous mandons que ses diz gaiges vous lui paiez par chascun mois qu'il sera oudit service et jusques à ce que vous en aiez lettres de nous de cassement; et aussi vous mandons que vous lui faciez baillier et delivrer par juste et loial pris que vous paiez des deniers du roy, fer, acier, buche, charbon, forge, soufflés et tous autres habillements dont il vous requerra qui seront nécessaires aux ouvrages des canons qu'il nous a promis à faire, en prenant de tout ce lettres de recognoissances par lesquels rapportant avec ces présentes, tout ce que paiez aurez pour ceste cause, vous sera alloué en voz comptes sanz contredit. Donné au Pont l'Abbé sous nostre seel, le premier jour de Novembre, l'an mil CCCLX et quatorze.

"Par monseigneur le lieutenant,

"Signe, LE GUES."

Girart had completed the manufacture of one cannon on the 4th May, 1375, and calls himself, in a receipt for his materials, "cannonier et

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[1] B. R. orig. parch. au cabinet généalogique, série des titres originaux.

[2] The author desires to modify the opinion expressed in his last paper that the stones mentioned in the directions for the defence of Montauban were intended as projectiles for cannon. He now considers that there are good grounds for believing these stones were to be thrown on the besiegers heads at close quarters, as shewn in the directions for the defence of Bioule.

[3] Vol. III. p. 96.

gouverneur du grant canon qui fut fait à St Lô pour le fait de St Sauveur."[1] We have no further particulars of the size or method of manufacture of this cannon; but the archives of the empire[2] have preserved the most minute account of the charges for and material used in the manufacture of another great cannon weighing more than 2000 lb., constructed at Caen in the same year, and for the same siege, under the superintendence of Bernard de Montferrat, "maistre des canons."[3]

On the 20th March, 1375, an order was received at Caen, from Jehan le Mercier, one of the king's councillors, for the manufacture of a "grant canon de fer," and "Bernart de Montferrat, maistre des canons" was instructed to superintend the arrangements. The 21st and two following days were spent in erecting three forges in the market place, and surrounding them with a wooden paling, to protect the smiths from interruption. On the 22nd, three master smiths, and one smith not designated as a master, but receiving the same pay, commenced to draw wages. They had eight workmen to assist them and a man to supply the forges with fuel, charcoal powdered through a sieve, and to blow the bellows. Three other smiths, with the same wages, worked on the 26th and 27th only, and were again employed with others for short terms towards the middle and end of April. They all continued at work, with the exception of Sundays, and Monday the 23rd April, which must have been a holiday, until the 3rd May inclusive, and on the 3rd April, one Jehan Nicolle, a master smith, arrived from "Sap," whence he had been brought at the public expense, because he was said to be the best workman in iron in all the country of Normandy. The entire manufacture of this cannon employed an average number of fifteen men for six weeks; and they appear to have sometimes worked at night; for there is an item "pour chandelle pour ardre par nuyt quant on forgoit."

In the manufacture of the cannon itself, 2110 lb. of wrought-iron, and 200 lb. of steel were employed. Of the wrought-iron, 650 lb. went to form the "cuve." This "cuve" (probably the inner tube or barrel of the cannon, afterwards surrounded with rings) was made entirely of "fer d'Espengne plat," which cost 6*d.* per lb.: while the remainder of the cannon was made of "fer d'auge," and "fer d'Espengne" of apparently inferior quality, as it cost less than 5*d.* per lb. We are not told for what portion of the cannon the steel was used. The "esseulx et chevilles" bolts and pins, necessary for fixing the cannon in its bed and making the bed itself, were made from 365 lb. of iron of both descriptions. The bars of the cannon were probably welded together, and then surrounded with circles of wrought-iron having rings attached to them, for we read of an anvil hired: "le louage d'une bigorne en quoy les sercles, lians et agneaux du dit canon ont esté dréchiez et mis à point."

The whole piece was bound entirely round with rope, of which nearly 90 lb. were bought for this purpose, and was covered over all with a cow-

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[1] B. R. orig. parch. cabinet généalogique série des tit. orig.

[2] Archives de l'Empire. Régistre coté KK. 350 et intitulé au dos *Comptes de la rançon du roi Jean, diocèse de Bayeux*, F°. 246, and F°. 254, et seq.

[3] The documents from which this description of the manufacture of cannon at Caen has been drawn, are printed entire by Napoleon in the Etudes, Vol. IV. Appendix, p. xviii. et seq. They occupy twenty-seven pages 4to. It is therefore impossible to reproduce them here.

hide, sewn round to keep out the rain, lest the iron should rust, or the cords decay; "affin que il ne pleust dessus, que le fer ne rouillast ne que les cordes ne pourrissent." The vent, "pertus par où l'en mettait le feu ou dit canon," was covered with a large iron apron (*grant plataine de fer*) fastened with a bolt, in order that the rain might not enter the vent when the cannon was loaded, "affin que il ne pleust en icellui quant il seroit chargié."

The bed of this cannon comprised a large piece of elm to encase the body of the cannon;—another portion for the side-pieces (*jumelles de son siége*):—a large piece of elm for the front side-pieces (*jumelles de devant*) for lowering and raising the cannon when required :—three pieces of wood for the *patrons*, &c.:—a piece of oak for the rear side-pieces (*jumelles de derrière*):—two great pieces of wood for the two lower beams (*deux solles de desouz*) to carry the cannon :—wood to make the long bands (*lons lyans*) &c. :—four pieces of wood for the *chappeaux* and *petits lyans*, &c. Forms of beds for cannon exactly corresponding to this description are to be found in the 15th century MSS.; and the present instance will be again referred to when those designs are reproduced.

After the cannon had been "lié des sercles et mis en bois," it was found necessary to purchase four pulleys to direct it (*gouverner*), as it was impossible to control it by any other means. It was proved before being sent to the siege. Four stones were ordered for the proof, but as two of them accompanied the cannon to the siege, evidently only two proof rounds were fired. Each stone cost 2*s*. 6*d*.

When the cannon was quite ready (*tout prest de jeter*), it was removed with two stone shot, all its siege bed, its bands of iron, and pins and wedges of iron and wood, to the place (Saint Sauveur le Vicomte) where it was destined to play its part. It was dismounted for transport, and remounted for the siege, as we learn from an item for baskets to carry the iron and wooden bolts, &c., "que estoient nécessaires pour le siége d'icellui."[1]

On the 5th May, the receiver of Caen himself started to accompany this cannon, made at so much cost, to its destination of St Sauveur le Vicomte, and completed his return journey on the 10th May. He had scarcely been home a fortnight, when orders were received from the king, dated 25th May, to make certain other cannon for the same siege. In the archives of the empire[2] are also preserved the accounts of their manufacture, which was superintended by four master smiths, who commenced their labours on the 28th May, and ended them on the 15th June. In making three cannon, they used 1449 lb. of iron, and 25 lb. of steel, thus allowing a weight of less than 500 lb. to each of them, though in one part of the account they are designated great cannon.

At the same time twenty-four cannon were *cast*, which in one place are called "canons de cuivre," though the metal purchased for their material is styled "mitraille." This "mitraille" probably consisted of small fragments of brass or bronze; 421 lb. only were employed for 24 cannon, so that their average weight was but 17 lb. or 18 lb. This was of course

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[1] The whole of this account presents features of extreme interest to the student of the archæology of cannon, and is well worth a careful perusal.

[2] Archives de l'Empire. Reg. KK. 350, F°. 273.

an expensive material, 20*d.* per lb. being paid for it, and 12*d.* per lb. to the founder for casting and finishing the cannon.

At the same time there were purchased ready forged five small iron cannon at a price of less than 2*l.* each.

The three large cannon were encased (*encassés*) in large pieces of elm when it was required to fire them; and there are also items for helving or handling (*pour emmancher*) the 24 copper, and 5 small iron cannon, with wood. The small cannon appear to have been bound to their stocks before removal to the siege; but the bands, bolts, pins, wedges, gudgeons, &c. (*lians, chevilles, broches, tappons, gougons,* &c.), for the three large cannon were taken separately in baskets, as we have seen was the case with the large cannon made some weeks before.

Three round stones costing 1*s.* 4*d.* each, were provided for each of the three large cannon, and 100 lb. of lead to make bullets for all the small cannon.

Thirty-one pounds of powder at 10*s.* per lb. was the quantity supplied for the whole number of pieces,—

"xxxi livres de poudres de canons, pour charger tous les diz canons: c'est assavoir, iii grans getans pierres, xxiiii de cuivre getans plommées et v de fer semblablement gettans plommées, lesquieux furent tout prest de geter, pour chascune livre x. s. valent.....pour ce, xv fr. et demi."

The stores for their service included iron hammers,[1] shovels for holding the charcoal, bellows for blowing the fire, &c.; the same articles, in fact, which occur in every account at this time.

We have only to compare the prices of the materials here enumerated to see how the very great cost of gunpowder must have retarded the advance of the art of gunnery:

Iron cost from	5*d.* to 6*d.*	per lb.
Gun metal ,,	20*d.*	,,
Steel ,,	10*d.*	,,
Lead ,,	10*d.*	,,
Gunpowder,,	120*d.*[2]	,,

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[1] A curious error occurs here in the Etudes. The words "marteaux de fer," which clearly express iron hammers, used with cannon at every gate at Arras, and indeed found wherever cannon and their stores are enumerated, are read "morceaux de fer," and the author of the Etudes argues, Vol. III. p. 99, that they were elongated projectiles. There can be no grounds for such a suggestion. Indeed the following words express clearly that the *marteaux* were employed to drive the shot home: "pour porter à la place avec les diz canons, *pour yceulx charger* se mestier estoit."

[2] Considered in relation to the ordinary commodities of life, money had then more than ten times its present value. It is interesting to compare, on this basis, the prices of these materials in 1375, with their present prices four hundred and ninety years later.

	Price per lb. in 1375 multiplied by 10.	Price per lb. in 1865.
Iron	4*s.* 2*d.* to 5*s.*	1*d.* to 1½*d.* (bar iron, average quality).
Steel	8*s.* 4*d.*	4½*d.* to 9*d.*
Gun metal	16*s.* 8*d.*	12*d.*
Lead	8*s.* 4*d.*	2*d.*
Gunpowder	£5.	7*d.* (Waltham Abbey).

It is remarkable that these cannon were all loaded before being removed from Caen, and in that state taken to the siege: this is shewn by more than one item of the account. First we have

"A Guillaume de Saint Vigor, pour c livres de plon, de lui achaté pour mettre en pelotes, pour charger les canons pour porter au siege, et pour yceux recharger à la place se mestier estoit....."

Again,

"A Pierre Roillart, pour sa paine et sallaire d'avoir charroié de Caen au siège et d'illecq à la place III grans canons de fer, XXIIII de cuivre et v autres petits de fer, tous chargés de pierre et de plommées, le boys, les chevilles, les gougons, et toutes les choses nécessaires pour yceulx faire geter....."

Other items confirm the above, and we can thus see the necessity for the vent-cover, if the cannon had to lie for days loaded and ready to be fired.

Cannon of considerable size seem now to have become common throughout France. Froissart mentions 140 cannon used at the siege of Odruik by the Duke of Burgundy, in 1377, which threw projectiles of 200 lb. weight:

"Et là jetoient les canons, dont il y avoit jusques à sept vingt, carreaux de deux cents pesant, qui pertuisoient les murs; ni rien ne duroit devant eux....."[1]

Later in the year William de Weston was tried before the English Parliament for surrendering this castle of Odruik or Outherwyk, as it is called. He made the following defence:—

"Plese vous savoir coment par un Lundy, houre de prime, viendront les Enemys par le dit Chastel asseger à la nombre entour ii m. et VI. c. hommes d' armes et VII C. arblasters de genevoys ovesq v. m. de la communauté de pays cientz IX grosses cannons, un grant engyn, et un trebuchet outre ascun mesure que l'en avoit unges vien par devant en cettes marches."[2]

Thus the statement of Froissart as to there having been large cannon employed here is confirmed by excellent evidence, but the number is considerably reduced. Indeed throughout this and all other chronicles the numbers of troops &c. must be accepted with considerable caution. We see here that the cannon had not yet entirely superseded the trebuchet.

At Ardres, earlier in the same year, the French "firent dresser et appareiller leurs canons qui portoient carreaux de deux cents pesant."[3]

It is remarkable that the projectiles here used should be called "carreaux." It is unlikely that the form of the arrow should have been retained for projectiles of so great weight; and we prefer to suppose that Froissart uses the word in the general sense of a projectile for cannon. We have no reason for believing that iron shot had as yet been fabricated in France, and must therefore conclude that these projectiles were of stone. The fact of their piercing the walls is also of great importance, as we have here the first

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[1] Froissart, Vol. I. ch. 390, p. 716.
[2] Rolls of Parl. 1 Rich. II. (1377, p. 10).
[3] Froissart, Vol. I. ch. 389, p. 714.

indication of the breaching powers of cannon, destined ere long to bring about a great change in the existing systems of fortification. Projectiles of equal size and even of equal weight had probably been thrown from many of the large trebuchets; but not horizontally, nor indeed with such velocity as could be obtained from gunpowder, ill made though it was at this time.

But these large and heavy projectiles of 200 lb. weight were not by any means the greatest employed at this period; nor are we dependent on the statement of the chroniclers alone; for in the same year 1377, we read in a contemporary account of a cannon to throw a projectile of 450 lb. weight, made for the Duke of Burgundy, the construction of which occupied three months, or twice as long a time as that employed in the manufacture of the largest cannon at Caen. This account is to be found in a work[1] professing to be entirely compiled from contemporary MSS., and from the second part we give the following extract:—

"Les Ducs de Bourgogne avoient de l'Artillerie, et plusieurs officiers qui en avoient soin. En un compte rendu par Simon Lambert en 1377, il est dit qu'il fut fait un canon à Châlons pour Monseigneur le Duc jettant le pesant de soixante livres, que ledit canon fut enchâssé en un plot de bois. Autres canons faits audit Châlons, dont l'un pesoit 130 livres, l'autre cent livres, un autre 90. livres, & deux autres, l'un de 30. & l'autre de 20. livres. Pour autres deniers payez pour monseigneur, par lui dus pour la forge et façon d'un gros canon jettant le pesant de quatre cent cinquante livres, fait à Châlons du commandement de mon dit seigneur par Jacquet de Paris, et par huit ouvriers de forge avec luy, par l'ordonnance de Jacquet et Rolant de Maillorques, Maîtres des canoniers d'iceluy Seigneur, lequel canon fut commencé à faire le lundi apres la Fête S. Denys, 12e jour d'octobre 1377, et fut parfait et assis le samedi après la fête de l'apparition de Notre Seigneur, 9e jour de Janvier l'an que dessus."

There is no reason for doubting the accuracy or good faith with which this account is rendered; and indeed there is nothing improbable in the fact itself. We have an existing cannon of only a few years later, the projectiles of which must have been of even greater weight than this. A stone round shot of 450 lb. weight would probably exceed 21 inches in diameter, and the well known bombard of Ghent has a bore of 26 inches.

Thus there seem to have been, in France at least, no slow intermediate steps between the small breech-loading and muzzle-loading cannon projecting arrows and leaden bullets of less than 2 lb. weight, and the gigantic cannon, hurling its massive stone, which must have broken and shivered any obstacle except strong masonry. Gunpowder was still, however, pounded by hand in a mortar, as we learn from accounts in the archives of Lille, dated 1381, where we read amongst other items,

"Pour l'accat d'un mortier et le pestiel de fer à faire pourre de canons."[2]

In the same accounts for the following year (1382) mention is made of leaden bullets weighing together 486 lb., and immediately afterwards of cannon which by their price were evidently but small: then of great cannon

[1] Mémoires pour servir à l'histoire de France et de Bourgogne, contenant un journal de Paris &c., &c. 2me partie. Mémoires pour l'histoire de Bourgogne. Etat des officiers et domestiques de Philippe, dit le Hardy, Duc de Bourgogne. Paris 1729, p. 64.

[2] Etudes, Vol. III. p. 103.

throwing stones, of stone shot weighing 12¼ lb. each, and of small stone shot weighing 7 lb. each.[1]

In these accounts first occurs in the French language the word "bombarde," which is repeated several times during these years 1381–82. In 1381, a bombarde cost 20*l.* 12*s.* 6*d.* Two hundred and sixteen "pieres de bombarde moitié grandes et l'autre petites" cost "XII*l.* pour le cent l'une pour l'autre."

A long and very interesting extract from these archives is given in the Etudes, Vol. III. pp. 103–106: but few new facts are to be gathered from it. We learn, however, that the hammers so constantly supplied were used to drive in the projectiles:

"A lui pour I martiel à cachier[2] plommés de canon mis à le porte du moliniel, VIII. *s.*"

The small cannon so much in use at this period are called by Froissart, in speaking of the passage of the Lys in 1382, "bombardes portatives." He says,

"Adonc vinrent arbalêtriers et gens de pied avant; et si en y avoit aucuns qui jetoient de bombardes portatives, et qui traioient grands quarriaulx empennés de fer, et les faisoient voler outre le pont jusques à la ville de Comines."[3]

On this occasion arrows appear to have been thrown by the cannon; and occasionally the French discharged fiery projectiles from them. Thus we read that when the French were before Bourbourch, the soldiers were anxious to take it by force in order to obtain the plunder, which would not be theirs, should the town quietly surrender; so they skirmished, and

"Les choses monteplièrent et s'enfelonnèrent tellement que les François trairent le feu en la ville par viretons, par canons, et par sougines, et tant que maisons furent éprises et enflambées, &c."[4]

Instances of this employment of cannon will however more frequently appear in speaking of the English method of warfare.

The work already quoted[5] on p. 12 produces another account relating to the Duke of Burgundy's artillery, in which it is mentioned that in 1394, the corporation of Dijon lent him two copper cannon, and a large cannon, with twelve round stones, for his use at Montmorot. The duke seems also to have had regular officers in his pay called "maitres des canons" and "canonniers;" but their wages were considerably less than those of his valet.

It would be tedious to bring forward further instances all tending to the same conclusion, that in France until about the year 1375, the only cannon in use were small, and the only projectiles employed lead and arrows; that

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[1] Etudes, Vol. III. p. 103.

[2] The word "cace" or "cache" has already occurred in the sense of a rammer. It appears that the rammer, "cace" or "poussoir," must have been placed against the shot, and struck with the hammer.

[3] Froissart, Vol. II. ch. 181, p. 235.

[4] Ibid. ch. 215, p. 287.

[5] Mémoires pour servir à l'histoire de France, &c.

in or about this year large cannon were first forged, and huge stone projectiles employed, and that when once the stone shot had been introduced they were made of all sizes from 7 lb. to 450 lb.; while lead, slowly superseding the more bulky cannon-arrow, was still in use for the smaller and portable guns. At the close of the century there must have been in France cannon of every calibre from less than two inches to nearly twenty-two inches; and if the secret of granulating gunpowder had been discovered, no stone walled castle could have withstood for a day the breaching batteries which would have been brought to bear on it. Still however the costly ingredients were finely powdered by hand, and the other large engines of war still formed a large proportion of the artillery used in sieges and defences. Iron shot have not yet made their appearance in France.

The Flemings were not behind the French in the matter of artillery, and Froissart gives us many instances of the uses to which their cannon were applied. When they were besieging Audenarde in 1379, we read that the fire of their cannon was such as to cause the defenders to cover the roofs of their houses with earth.

"Pour le trait des canons et du feu que les Flamands lançoient et traioient soigneusement en la ville pour tout ardoir, on avoit fait couvrir les maisons de terre, par quoi le feu ne s'y pût prendre."[1]

Again at Tenremonde, the assault is described as long and horrible:

"Car ces Flamands avoient apporté, en leurs nefs, canons dont ils traioient les carreaux si grands et si forts, que qui en étoit consuivi, il n'y avoit point de remède qu'il ne fût mort. Mais à l'encontre de ces carreaux on êtoit moult pavesché..."[2]

In the year 1382, an instance of the employment of cannon as a defence in the field is brought to our notice. They were small, and placed on wheeled carriages, protected in front by spikes projecting beyond them. When the army was arranged in order of battle these carriages, which were called "ribaudequins," were placed in front as a protection from the enemy's attack.[3] In the present case we read in Froissart[4] that the men of Ghent, making war on the town of Bruges, set off towards the latter town;

"Et furent environ cinq mille hommes et non plus; et chargèrent environ deux cents chars de canon et d'artillerie....."

When they had arrived near to Bruges, "Se fortifient ils à l'une des parts et à l'autre lez de leurs charrois;" and then,

"Ils se mirent en l'ordonnance de bataille et se quatirent tous entre leurs ribaudeaux. Ces ribaudeaux sont brouettes hautes, bandées de fer, à longs picots de fer devant en la pointe, que ils seulent par usage mener et brouettes avecques eux; et puis les arroutèrent devant leurs batailles, et là dedans s'enclòirent."

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[1] Froissart, Vol. II. ch. 58, p. 80.

[2] Ibid.

[3] Of these wheeled carriages containing cannon and protected by pikes, we shall meet with other instances at a later date. See Christine de Pisan, Livre des Faits d'Armes, ch. 26, fol. 36. Pierre de Fenin. p. 550, Panthéon litteraire. Monstrelet, ch. 84, p. 205.

[4] Froissart, Vol. II. ch. 154, p. 203.

The editor (M. Buchon) says in a note to the word "ribaudeaux,"

"Je lis dans un autre manuscrit 'Iceux ribauldequins sont trois ou quatre petits canons rangés de front sur hautes charrettes en manière de brouettes devant sur deux ou quatre roues bandées de fer, atout longs piques de fer devant en la pointe."[1]

But while the Flemings were thus employing the smaller natures of cannon, they had not neglected to take the same step forwards in the manufacture as their French neighbours. At the siege of Audenarde in the same year, by Philip van Artevelde, the besiegers, in addition to trebuchets and other large engines, made use of a

"bombarde merveilleusement grande, laquelle avoit cinquante trois pouces de bec, et jetoit carreaux merveilleusement grands et gros et pesants; et quand cette bombarde descliquoit, on l'ouoit par jour bien de cinq lieues loin, et par nuit de dix; et menoit si grand' noise au descliquer, que il sembloit que tous les diables d'enfer fussent au chemin."[2]

A most graphic description this of the great bombard, but antiquaries dispute as to the meaning of the "cinquante trois pouces de bec." If by the word "bec" we may understand the mouth or muzzle of the cannon, the fifty-three pouces, or sixty inches must represent the circumference and not the diameter of the circle. This would allow a calibre of nearly twenty inches, almost as great as that of the cannon made for the Duke of Burgundy in 1377, and, as already explained, no larger than other existing specimens. It has frequently been suggested that the great bombard now at Ghent, and which certainly dates from as early a period as the first half of the fifteenth century, was no other than this very cannon of which Froissart gives such a terrible description. It has a bore 2 ft. 2 in. in diameter, and is 16 ft. 4 in. long; and we can well imagine that when a shot was propelled from such an engine, with so large a charge of powder as must have been used, it may well have seemed to the bystanders as if *tous les diables d'enfer fussent au chemin*.

We know how the approach of the army of Charles VI. compelled Philip van Artevelde to raise the siege of Audenarde, and the sad end of the fatal day of Rosebecque, on the 29th November, where Philip himself and 15,000 Flemings are said to have been slain. We are told by Froissart[3] that at this battle the Flemings advancing "commencèrent à traire et à jeter des bombardes et des canons gros carreaux empennés d'airain; ainsi se commença la bataille."

The effect of this discharge was to make the French army recoil "one pace and a half." But this army differed greatly from that which the Flemings had encountered at Bruges; it was composed of the flower of French chivalry,

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[1] Monstrelet describes them in 1411 as having mantlets before them and carrying one or two large cannon (*veuglaires*). A design apparently made from these descriptions appears in a work by Jean Appier Hanzelet Lorrain, published at Pont à Mousson in 1630, called "Le Livre de Pyrotechnie." The Emperor Napoleon (Vol. I. p. 38), considers this as a reproduction of a figure from a rare and old manuscript, and copies it; but there is no interior evidence of this in Hanzelet's work, and we cannot therefore accept the figure as an authority, although Napoleon does so without hesitation.

[2] Froissart, Vol. II. ch. 161. p. 214.

[3] Ibid. Vol. II. ch. 197, p. 250.

and commanded by Charles VI. himself; as soon as the artillery had been once fired, its part was played, and when the militia of Ghent had to encounter hand to hand the veteran chivalry of France, there could be no doubt of the result.

This battle did not, however, terminate the struggle. Aided by the English, the men of Ghent invested the town of Ypres on the 8th June, 1383. They were supplied with artillery, but of so feeble a nature, that not one single man of the besieged was wounded by it, although the siege lasted till the 8th August, and though, as we learn from the chroniclers, two cannon, which were placed before one of the gates, never ceased firing day and night, from the 15th June, each discharge being preceded by a trumpet-call. They fired 450 shots, and beat in the doors of the gate, but the siege was abandoned.[1]

The Flemings and the Liégeois were in turn allies of Brabant during the wars with Guelders in the closing years of the century; and we learn from the accounts of Malines,[2] which town at this time (1388) belonged to Flanders, that its cannon and engines were sent to the war; and Froissart[3] relates the effect of the cannon at the siege of Grave in that year.

Indeed throughout Belgium this epoch was very favourable to the rapid development of these new weapons, for the constant struggles between the people and the feudal powers led to the adoption of every project which might contribute to their chance of victory.

For the history of English cannon, during the second half of the fourteenth century, we have but scanty materials. Few documents bearing on our subject have yet been discovered, and we can with difficulty obtain information as to the size and nature of the cannon employed by the English at this time. According to Froissart, they appear to have been used, not only for throwing shot and arrows, but also (in the earlier and first meaning of the word), as tubes for propelling Greek fire and other incendiary compositions. He tells us[4] that when the French under King John were besieging the castle of Breteuil in 1356, then in the occupation of the English troops, the French filled up the ditch of the castle, and entered a beffroy[5] which they had made. The garrison saw this beffroy and knew the best way to assail it. They were provided with cannon to throw fire and great arrows; and they made their arrangements to assail the beffroy and to defend themselves. Before firing their cannon, however, they attacked the occupiers of the beffroy hand to hand, and great feats were performed on both sides; but when

"ils se furent plenté ébattus, ils commencèrent à traire de leurs canons, et à jeter feu sur ce beffroy, et dedans, et avec ce feu traire épaissement grands carreaux

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[1] Vereecke. Histoire militaire de la ville d'Ypres, p. 53, et seq.

[2] Accounts 1387—88. Henrard, Histoire de l'artillerie en Belgique. Bruxelles, 1865, p. 35.

[3] Froissart, Vol. III. ch. 114, p. 707.

[4] Ibid. Vol. I. Part 2, ch. 21, p. 332.

[5] The beffroy was a large moveable tower on wheels. For a description of the beffroy and its use in sieges, see Napoleon's Etudes, Vol II. p. 16.; and for an admirable picture of one, see M. Viollet Le Duc's "Architecture Militaire."

et gros, qui en blessèrent et occirent grand' foison, et tellement les ensonièrent que ils ne savoient au quel entendre. Le feu, qui étoit grégeois, se prit au toit de ce beffroy, et convint ceux qui dedans étoient issir de force, autrement ils eussent été tout ars et perdus....."

Later in the same year, the Black Prince was besieging the castle of Romorentin, when he gave orders,

"à apporter canons avant et à traire carreaux et feu grégeois dedans la basse cour: si cil feu s'y vouloit prendre, il pouroit bien tant monteplier qu'il se bouteroit au toit des couvertures des tours du châtel, qui pour le temps étoient convertes d'estrain:..... Adonc fut le feu apporté avant, et trait par bombardes et par canons en la basse cour, et si prit et multiplia tellement que toutes ardirent....."[1]

If the first of these cases leaves any doubt as to whether the Greek fire was cast by the cannon or by other means, the last quotation must remove it. But we must rest satisfied with the fact that fire was so thrown, as we have no information as to the manner in which the cannon were made to serve this purpose.[2]

The fact that the English artillery was not required for home service, but for foreign invasion, and that, as far as we can judge, the English did not make their own cannon, will account for our finding so few documents relating to guns, and none relating to their manufacture, among the English records. Mr Hunter, in a paper on the early use of gunpowder in England,[3] informs us that in the 34th Edward III. (1360), there were only four guns of copper and 16½ lb. of gunpowder in the privy wardrobe, which was, as shewn in a former communication, the repository of the king's weapons of war; and one of these guns, with many arrows and bows, was taken by Lionel Earl of Ulster, when he went to Ireland. This scarcity of guns in England at that time was, however, probably caused by the demand for foreign service, which continued to drain the kingdom of military stores; for again, in an account of John de Sleford, clerk of the wardrobe, arms, &c., 38-43, Edw. III. 1364-1369:[4] there occurs,

"Item, found in the said private wardrobe of the king two great guns of copper,"

and no other mention of cannon.

Calais, as Mr Hunter informs us, was in those times scarcely less than the Tower a depôt of military stores. William de Redeness was keeper of the king's stores there in 1369, and the two following years; at which time there were in his charge 15 guns, 995 lb. of saltpetre, 1298 lb. of sulphur, three great guns of brass, and one of iron, 224 balls of lead, 84 lb. of gunpowder, &c.[5] Calais was indeed the English base of operations throughout the French campaigns of this period, and we find that the English troops

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[1] Froissart, Vol. I. Part 2, ch. 26, p. 337.

[2] A short description of the Greek fire and its introduction into Western Europe, may be found in Major Owen's Lectures on Artillery, 4th Edition, pp. 4–6.

[3] Archæologia. Vol. XXXII. p. 384.

[4] Roll marked F. L. H. 532, published by Sir Harris Nicolas, History of the Royal Navy, Vol. II. App. p. 477.

[5] Archæologia. Vol. XXXII. p. 384.

carried cannon about with them on their march through the country. When the troops of Sir John Chandos were besieging Montsac in 1369, they, "levèrent devant les murs aucuns canons qu'il portoient,"[1] and in the same year before La Roche-sur-Yon, they had "plusieurs canons et espringalles, qu'ils avoient de pourvéance en leur ost, et pourvus de longtemps et usagés de mener."[2]

According to Cuvelier, a troubadour of the 14th century, bombards were used by the Black Prince at Najara in 1367, but Froissart is silent on the subject, though he especially notices the Spanish slings. Cuvelier says that the English weapons included

"Bombardes, ars à tour, espées et espois."[3]

It is very probable that the English did carry with them some small bombards, to be used whenever a castle was to be besieged.

The department of gunnery in the Tower appears to have become of sufficient importance in or before the year 1370 (44, Edw. III.), to have had an officer of its own under the keeper of the wardrobe. An account rendered by this officer of his receipts and expenses, from the 1st March 44th year (1370), to 31st March (48th year) 1374, is given by Mr Hunter in Archæologia,[4] and as that publication is probably accessible to but few of those for whom these papers are designed, and the account presents features of great interest in connection with early English cannon, it is here re-published.

"Particule compotis Johannis de Derby de omnibus receptis expen. et custag. per ipsum fact. pro gunner. R. a primo die Martij anno xliiij° usque ultimum diem eiusdem mens. anno xlviij°.

Rec. denar. { Idem reddet compotum de *xxiiij.li. xij.s. v.d.* recept. de Johanne de Sleford clerico private Garderobe Reg. infra Turrim London. per divers. vic. per temp. huius comp.
Summa xxiiij. li. xij. s. v. d.

Empt. divers rerum. { Idem computat in bagg. de coreo oll. et patell. terr. fagot. salic. talwod. et al. necessar. divers. offic. gunner. tangent. empt. et expend. super factur. pullveris et pil. plumb. pro gunner. necnon cariag. portag. et batell. plumb. barell. cum sulfur et salpetr. et al. rerum predict. de diversis locis usque Turrim London. Quenesburgh. et alibi una cum vadiis divers. operar. operanc. et laboranc. circa pulveres et pil. plumb. predict. faciend. et fundend. infra tempus huius compoti *cxvj. s. vj. d.* Et in ij. mort. eneis iij. pestell. ferr. xij. coclear. ferr. pro pil. plumb. fundend. x. form. de laton. pro eisdem pil. faciend. j. par. balanc. xxx. barell. parv. cum garnett. hasp. et stapul. pro pil. plumb. inponend et custodiend. viij. al. barell. maioribus pro pulv. xxx. cerur. parv. pendent. pro predict. xxx. barell. ccxx. lb. salpetr. ij sars. et xviij. belowes empt. ad diversa precia infra dictum tempus *xix. li. viij. s. ij. d.*

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[1] Froissart, Vol. I. Part 2, ch. 273, p. 579.

[2] Ibid. ch. 284, p. 585. This usage of carrying cannon was cited as one of the arguments that cannon were employed at Crecy. See "Proceedings," R.A. Institution, Vol. IV. p. 298.

[3] Chron. de Bertrand du Guesclin par Cuvelier, line 11,069. Paris 4°, 1839.

[4] Archæologia, Vol. XXXII. p. 386.

Summa xxv. li. iiij. s. viij. d. Et habet superplus. xij. s. iij. d.

Idem redde ij. mort. eneis. iij. pestell. ferr. xij. coclear. ferr. x. form de Laton. j. par balanc. xxx. barell. parv. cum apparatu viij. al. barell. maioribus xxx. cerur. parv. pendent. ccxx. lb. salpetr. ij. sars. et xviij. belowes de emptione ut supra. Et de j. cista flandr. xxix. gunn. ferr. vj. martell. ferr. xxviij. drivels ferr. xxviij. firingyrens ferr. xiij. patell. ferr. x. par. forcipum ferr. pro form. predict. j. carr. vj. wag. plumb. j. pipa et ij. barell. salpetr. pond. pur. M. liiij. lb. recept. de Johanne de Sleford. Et de j. wag. et vj. clav. plumb. rec. de Willielmo de Sleford. clerico operac. R. apud Westm. Et de j barell. de sal. geme cc. lb. salpetr. xij. gunner. de laton. et ij. barell de sulfur. vyf. pond DLxvj. lb. rec. de Helmingo Leget. De quibus

Rec. divers rerum.

Idem computat in devastione et casual. perditione circa operac. pulver. et pil. plumb. et diversis viag. R. infra tempus predict. v. colear. ferr. j. par. balanc. vij. barell. parv. cum apparatu viiij. barell. maiora xxx. cerur. j. sars. xj. belowes ccxij. lb. salpetr. ciiij^{xx}. lb. sulfur. iij. gunner. ferr. j. gunner. de laton. ij. martell. ferr. xv. drivels ferr. xj. firingyrens iiij. wag. vj. clav. plumb. Et in expens. iij^{c}. xx. lb. salpetr. et cvij. lb. sulfur. vyf. fact. in pulver. et expend. in predict. viag. et vj. wag. et xxj. clav. plumb. in pil. expen. in eisdem viag.

Devastatio expen et liberae, divers rerum.

Et idem computat liberasse predict. Johanni de Sleford ij. mort. enea iij. pestell. ferr. vij. coclear ferr x. form. de laton. cum x. par. forcipum ferr. xxiij. barell. parv. cum garnett. et al. apparatu ferr. j. sars. vij. belowes. j. cistam flandr. xxvj. gunner. ferr. iiij. martell. ferr. xiij. drivels ferr. xvij. firingyrens xiij. patell. ferr. j. carr. et xj. clav. plumb. in pil. fact. et ij. parvis peciis plumbi viij^{c}. vij. lb. salpetr. pur. ijc. xlij. lb. sulfur. pur. cxxxv. lb. salpetr. et xlix. lb. sulfur in pulv. fact. et xj. gunner de laton. et j. barell. de sal geme."

These accounts contain:—

(1) A statement of a certain sum received.
(2) An account of the expenditure of that sum.
(3) A receipt for the materials charged for in (2).
(4) „ „ other materials received.
(5) An account of expenditure by wear and tear, loss, and manufacture.
(6) Delivery-voucher of the balance of material to the keeper of the wardrobe.

The ordnance and stores which find a place here are,—

Guns, 29 iron, 12 brass.

Materials for powder, in sacks and barrels, 1474 lb. saltpetre, 566 lb. sulphur, willow faggots for charcoal.

For manufacture of powder, a pair of scales to weigh the ingredients; two brass mortars, and three iron pestles to grind them with.

For storage and porterage of powder, eight large barrels.

Materials for shot, lead, 1 carr., 7 wag., 6 clav.

For manufacture of shot, twelve iron ladles in which to melt the lead, ten brass moulds for the bullets, and ten pairs of iron pincers for removing the shot from the moulds. Brushwood for the fire, and bellows.

For storage and porterage of shot, thirty small barrels with "garnett," hasps, staples, and hanging locks.

For the service of the guns,—For loading, twenty-eight iron *drivels*,[1] six iron hammers. For firing, 13 iron pans to hold lighted charcoal, bellows to blow it, and twenty-eight firing irons, to be heated in the charcoal pans, and then used to fire the powder.

The size of the guns is not determined by these accounts. There are sufficient materials to make about 2600 lb. of powder, or about 65 lb. for each gun. Where the guns were made, or how, we have no information; twenty-nine were of wrought-iron, twelve of brass. The powder was pounded in a mortar, and the proportions were exactly three parts of saltpetre (320 lb.) to one of sulphur (107 lb.): the quantity of charcoal is not named. The leaden bullets were cast in brass moulds.[2]

John de Sleford, though he had so careful an assistant in John Derby, does not appear to have handed over into his charge all the guns and their stores at the Tower; for his own accounts for the same period have many interesting items connected with gunnery, and he acknowledges at the end of his accounts the receipt of the gunpowder and materials which John Derby names in his delivery-voucher. These accounts are given by Sir Harris Nicolas,[3] and neither he nor Mr Hunter seem to have been aware how the researches of each corroborated those of the other. They are as follows:—

Particulars of the account of John de Sleaford, clerk of the privy wardrobe, of armour, shot, gunpowder, &c., 46–48, Edw. III., 1372–1374.

Roll T. G. 674.

Payments for "helvyng" of eight guns and ten hatchets "ad modum pycoys," by agreement made in gross with a certain "joignour," 13*s.*; and &c. &c.

* * * *

And for wages of several workmen each at 6*d.* per diem, for various terms, in the making of powder and "pelottes" of lead for "gunnes" at the Tower of London, 33*s.*; and for one quarter of coal, price 10*s.*; and for talwood, bought for casting (*fundendo*) the lead and drying the powder, 5*s.* 2*d.*; and for willow fagots to make powder, price of the hundred 4*s.*

And for four "trays" of wood, price 3*d.*; and for brazen pots and dishes, price in the whole 13*d.*, bought for the drying of the same powder over the fire and by the sun, 2*s.* 1*d.*; and for leather bags to hold the same powder, 10*s.* 7*d.*; and

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[1] This word seems to correspond with the word "drift" which we now use in the service of artillery. They both appear to be derived from the verb to "drive," and to signify the piece of wood or iron placed between the mallet and the object which it is intended to drive in. The leaden shot seems to have been placed in the bore, and the drift or drivel held against it, and struck with the hammer. See the similar use of the *cace* or *poussoir*, foot note, p. 13, *ante*.

[2] The same Helmyng Leget who was keeper of the king's barges in 1338, again appears in these accounts. See Vol. IV. p. 291.

[3] History of the Royal Navy, Vol. II. Appendix, p. 479.

for two brass mortars, three iron pestles, twelve iron spoons, to make leaden bullets (*pil' plumb'*), ten moulds of "laton" to make the same; one pair of scales to weigh the powder; thirty small barrels with "garnett," hasps, and staples to hold and keep the leaden bullets (*pil' plumb'*); thirty small hanging locks (*serrur' parv' pend'*) for the aforesaid thirty barrels; 220 lb. of saltpetre, two "sarces," eighteen "belowes," twenty-four leather bags to "deliver" the powder; earthen pots and pans to dry the powder at the fire and sun; 400 fagots of willow for making charcoal thereof, and 100 of "talwode," and half a hundred of fagots, bought at divers prices by John Derby, clerk; and also boatage, portage, and carriage of lead, guns, barrels, and other necessaries, to divers places, together with wages of workmen and labourers upon the making of the powder, bullets, and charcoal aforesaid, for twenty-two days; likewise by the same John paid at divers times between the 1st day of March in the 44th year, and the last day of March in the 48th year, 25*l.* 4*s.* 8*d.*

To Stephen Smyth for 200 "pycoys" price 12*d.* each; for thirteen iron "patell'" for guns, price 5*s.* each; for two great guns of iron, price 40*s.* each; for forty iron "martels" for guns, price each 10*d.*; for twenty-eight iron "drivells" for the guns aforesaid, price 3*d.*; for twenty-eight firing irons price 2*d.*; for ten pairs of iron forceps, price 10*s.*; and for 120 quarrel heads for springalds, price 1*d.* each, bought for the king's voyage.....19*l.* 2*s.*

Of John Derby, of the remainder of his last account, 184 lb. of powder for "gunnes," proceeding from 135 lb. of saltpetre, and 49 lb. of sulphur vivum; 242 lb. of pure sulphur vivum.

Sum of the delivery of divers things.

* * *

Quarells, 44,351.
Iron guns, 29.
Guns of "laton," 1 great gun with 3 "pootz."

* * *

Barells, 1.

* * *

Iron cressets to cast fire, 4.

* * *

Iron martells, 6.
Dryvells of iron, 28.
Firing irons, 28.
"Patellæ" of iron, 13.
Iron forceps, 10 pairs.
Lead, 1 "carratt" and 6 "wagh."
Saltpetre, 1 pipe and 2 barrels, weighing 1050 lb.
Gunpowder, 60 lb.
"Moldes called formes to make bullets," 5.
Sulphur vivum, 126 lb.

Let us examine the chief points worthy of notice in these accounts. There is a payment for helving or, as we should say, handling eight guns together with some hatchets. This word "helvyng" exactly corresponds with the French "emmancher" noticed in the accounts of the receiver of Caen.[1] It signified the manufacture and attachment of the stocks for the small guns. That they were very small there can be no doubt, for two great guns of iron

[1] See page 10, *ante*. It is still a household word in the midland counties.

cost only 40*s*. The guns were made of iron or brass, and one great gun had three pots or chambers. This one seems to have been a breech-loader, but the others were not so.

The powder was made in the manner which we have already described, but we gain the additional information that it was dried over a fire or in the sun, in wooden trays, or brazen or earthern pots or dishes. It was then deposited in large leathern bags, and transferred to small leathern bags for distribution when required. The charcoal was entirely of willow; indeed the properties of this wood which made it so valuable for this purpose had been found out a century before. Sir F. Palgrave writes as follows:—

"Another of the works of Ferrarius, an unedited epistle addressed to one Anselm, preserved or buried in the Bodleian, is of very great importance in the history of science. * * * The MS. appears to be of the age of Edward I. It contains several receipts for making 'Greek fire' and 'Flying fire;' the second of which contains the mode of compounding the nitrate powder, composed of one part of sulphur, two of charcoal of the wood of the willow or lime tree, and six of saltpetre to be very finely ground upon marble or porphyry, &c. &c."[1]

The manufacture of the bullets, and their storage, was identical with that already described, and the stores or side-arms in no way differed from those accounted for by John Derby.

About this time was written a curious treatise, "Practica" by one John Arderne, an eminent surgeon of the time of Edward III. In it we find the following receipt:—

"Pour faire un fewe volant:—

"Pernez j. li. de soufre vif, ij. li. de charbones de saux, vi. li. de salpetre, si les fetez bien et sotelment moudre sur un piere de marbre, puis bultez le poudre parmy un sotille coverchief. Cest poudre vault à gettere pelottes de fer, ou de plom, ou d'areyne, ove un instrument qe l'em appelle Gonne."[2]

This projection of iron and brass balls by means of the gun was either a mere theory, or at most an experiment of the laboratory, unless Arderne had learned from the Italians to make use of these projectiles. Certainly neither the one metal nor the other had yet been used for shot in England, or in France: though in Italy in the first half of the century they were so employed. Indeed it is only at this time, corresponding almost exactly with the deductions drawn from French documents, that stone shot began to make their appearance in the English garrisons. Hitherto lead and arrows have been the only projectiles employed. But in 1378, as we learn from a document produced by Rymer, the king (Richard II.) gave directions to Thomas Norwich to purchase for the armament of the castle of Brest two large and two smaller engines called "*canons*," six hundred *stones* for these and other engines; 300 lb. saltpetre, 100 lb. sulphur, and a cask of willow charcoal. The original document is as follows:—

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[1] The Merchant and the Friar, by Sir Francis Palgrave, 2nd Edition. London, 1844. Preface, p. 11.

[2] Brit. Mus. Sloane MSS. 335 and 795: printed by Mr Hewitt, Ancient Armour &c. Vol. II. p. 293, and noticed by Mr Albert Way, in Promptorium Parvulorum, sub voce "Gonne."

"Rex universis et singulis vicecomitibus, &c.

"Sciatis quòd assignavimus dilectum nobis Thomam Norwich ad emendum et providendum, ad opus nostrum, per supervisum, dilecti nobis Thomæ Restwold, in civitate nostrâ Londoniæ et alibi, &c., pro denariis nostris, promptè in manu per manus dicti Thomæ solvendis, Duo magna et duo minora ingenia, vocata *Canons*, sexcentas Petras pro eisdem ingeniis et pro aliis ingeniis; Duodecim Balistas.....ccc. libras de saltpetre, c. libras sulphuris vivi, unum dolium Carbonum de Salugh, &c.

"Et dolia et barellos pro præmissis imponendis, pro stauro et munitione Castri nostri de Brest, &c.

T. R. apud Westmon".[1]

In Mr Devon's valuable collection of extracts from the Issue Rolls of the Exchequer, under date 10th December 1379, occurs the following interesting item.[2]

"To John Walssh, receiver of the king's provisions at Cherburgh. In money paid to him by John d'Arundell, marshal of England, late keeper of the castle and town of Cherburgh, at the time he was discharged from the custody aforesaid, for the undermentioned things remaining there for the king's use for the defence and provision of the castle and town aforesaid, viz: for ten guns to throw stones, two of which are of iron, and eight of other metal, seven of the said guns casting large stones twenty-four inches in circumference, and the three remaining casting large stones fifteen inches in circumference; 200 lb. of powder, 26 lb. of saltpetre, and 24 lb. of pure sulphur, were paid for at the exchequer in the account of the 17th day of June, in the eighth year &c."

Here we have iron guns, and others, doubtless brass, projecting stones of eight inches and five inches in diameter, not so large certainly as some of those mentioned by Froissart, but yet very formidable pieces.

At the same time that such large guns were in use for the armaments of fortresses, the small cannon were employed in considerable numbers in the attack. "An inquisition taken in 1375 at Huntercombe, (a place belonging to the Abbey of Dorchester), and now preserved among the records[3] at the chapter-house Westminster, states that one Nicholas Huntercombe, with others, to the number of forty men, armed with 'haubergeons, plates, bacenettes cum aventayles, paletes, lanceis, scutis, arcubus, sagittis, balistis, et gonnes, venerunt ad manerium de Huntercombe,' and there made assault, &c."[4]

In 1378, when the English were besieging St Malo, Froissart tells us that

"Si firent les seigneurs de l'ost ouvrer et charpenter manteaux d'assaut; et avoient en l'ost bien quatre cents canons mis et assis tout autour de la ville qui contraindoient durement ceux de dedans."[5]

To this the learned editor of Froissart's chronicles, M. Buchon, appends a note to the following effect:—

"Some modern historians consider that this number of 400 cannon is either exaggerated or erroneous. Others, among whom is Father Daniel, think that the

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[1] Fœdera. Vol. VII. p. 187.

[2] Issues of the Exchequer, by Frederick Devon. London, 1837, p. 212.

[3] Coram Rege, Hil., 50 Edw. III.

[4] Hewitt, Ancient Armour, &c. Vol. II. p. 298. This evidence was discovered by Mr Burtt.

[5] Froissart, Vol. II. ch. 29, p. 31.

cannon were very small. But possibly Froissart makes use of the word *cannon* in this instance, as a generic term for the various warlike engines employed in the attack of the town."

We are scarcely prepared to find so large a number of cannon carried by one army, and the author inclines to the opinion that the number is overstated, and also that the cannon were very small. Such guns, indeed, as these, and those named in the Huntercombe inventory can have been little if at all different from the hand guns, of later date. It may fairly be conjectured that these very small pieces were used as hand guns or fired from their carriages, as occasion might require. Many of those pieces which we have met with already, must, from their price and description, have been small enough to be so employed; and we know from MSS. of the following century that the hand gun was frequently only a miniature cannon encased in an oblong block of wood, which was allowed to rest on the shoulder of the person discharging it.

No further accounts of this half century possessing any great importance have been brought to light; but several entries in the Issue Rolls of the Exchequer prove that cannon were now in common use for the defence of castles. We hear of them at Carisbrook in 1379, from two different sources, and again at the same place in 1384; at Dover in 1372, and again in 1384; at Porchester in 1385, and at Rye in 1387: and we have already noticed them at Cherbourg and at Brest.

In 1379, the keepers of the castle of Carisbrook report the purchase of 100 lb. saltpetre at 15*d.* per lb., and 50 lb. sulphur at 6*d.* per lb. They also bought gunpowder and two brass cannon which cost £6. 6*s.* 8*d.*, early in the reign of Richard II.[1] The issue of the money for the above named saltpetre and sulphur occurs in the exchequer accounts.[2]

Another issue roll for 1384, is as follows: —

"To Sir Thomas de Beauchamp, knight, late Captain of Caresbrok Castle, in the Isle of Wight. In money paid to his own hands for so much money by him disbursed, viz.: to five canonniers, each having his cannon; and to one canonnier with three cannons, for the hire of the same canonniers and cannons, and for powder purchased for the same cannons late in the king's service in the retinue of the said Sir Thomas for the protection of the island aforesaid against the king's enemies, who in certain galleys at sea lately made an attempt to invade the island aforesaid. By writ of privy seal, &c., 26*l.* 5*s.*"[3]

This discloses the remarkable fact that cannon were, on some occasions, the property of private individuals, who hired their cannon and their own services at the same time, to the king for any special occasion. The fact seems clearly proved here; the words are "for the hire of the same canonniers and cannons." When the danger was over, they were dismissed, for the same cannons are said to have been "late in the king's service," which of course implies, no longer in such service.

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[1] Mr Hunter in Archæologia. Vol. XXXII. p. 384.
[2] Issue Roll. Easter, 3 Rich. II.
[3] Ibid. Michaelmas, 8 Rich. II.

In an indenture relating to the stores of Dover Castle in 1372, we find among the munitions of the fortress "cc. garbas sagittarum, vi. gonnes."[1]

The following bears date 1st May 1384:—

"To Sir Simon de Burley, Knight, constable of Dover Castle, for the price of 12 guns, 2 iron patellæ, 120 stones for the guns, 100 lb. of powder, and 4 stocks of wood, purchased of William, the founder of London, and delivered to the said Simon by the hands of William Hanney, clerk, for fortifying and strengthening of Dover Castle, 97*l.* 10*s.*"[2]

These guns projecting stones, with their shot, powder, and stocks, were bought from a London founder. Did he make the guns, or buy them from abroad in the course of trade, and then resell them to the king? It seems strange that it should nowhere be mentioned who was the maker of any of these English guns, and certainly as yet we are unable to state that any of them were either forged or cast at home.

On the 15th May of the following year there is an entry of money paid "for carriage of cannon &c. from the Tower of London to Porchester Castle for its defence;"[3] and two years later, 27th Nov. 1387, "wages of one canonnier, lately residing in the fortification of the king's town of La Rye."[4]

In the year 1400, under date 3rd May, occurs an item

"To Henry Roberts, sergeant, dwelling near Guildhall, in the city of London £8. 8*s.* for 24 'quarell gunnes,' at 7*s.* each; to William Olliver, grocer of Boklersbury, for 300 lb. saltpetre price 4*d.* per lb., and 100½ lb. pure sulphur at 4½*d.* per lb. &c. &c."[5]

Thus the small guns still threw arrows, or as elsewhere seen, lead; while stone shot and large guns were employed for fortresses. In England, as we see, the word "*gunne*" or "*gonne*" is more frequently employed than *canon*, though the latter does sometimes appear. Walsingham illustrates this curiously; he says "et illic figere vel locare gunnas suas, quas Galli canones vocant;" and indeed the *gonne* had in this half century become so common an engine of warfare as to furnish Chaucer with a simile, evidently intended to appeal to the common understanding. In the "House of Fame,"[6] written during the period of which we are treating, he says,

"As swifte as a pillet out of a gonne
When fire is in the pouder ronne."

Italy presented to our notice the first unquestionable voucher for the employment of cannon, and in Italy their manufacture was more rapidly developed than elsewhere. Iron shot were mentioned at Florence in 1326,[7] and brazen globes were named by Petrarch as early as 1344.[8] Judging by the price paid for projectiles at Ravenna in 1358, brass or bronze appears to have been the material employed. This information we obtain from some extracts out of the registers of accounts of Ravenna during the war with

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[1] Sloane MSS. 335 and 795, printed by Mr Hewitt. Ancient Armour, &c. Vol. II. p. 293.
[2] Issue Roll. Easter, 8 Rich. II.
[3] Ibid. Easter, 9 Rich. II.
[4] Ibid. Michaelmas, 11 Rich. II.
[5] Issue Roll. Easter, 1 Henry IV.
[6] Book iii. Ed. Chalmers.
[7] Vide Vol. IV. p. 289.
[8] Ibid. p. 296.

Forli in 1358, which also prove that cannon were manufactured at S. Archangel for especial employment in this war. We can estimate from the same source the weight of the projectiles employed, and the price of the powder and other stores for the cannon.

The original document is as follows :[1]

1358. Die ultim. Jun.

"pro 5 brachiis panni lini pro faciendo sachos pro retiendo pulverem bombardarum, sol. 19, den. 6.

pro 25 lib. salnitre pro pulvere bombardarum ad rat. 6*s.* et 3 den. pro libra... .....lib. 7, sol. 16.

pro una libra et 10 unciis sulforis pro pulvere bombard. ad rat. 3 sol. pro libra .....sol. 5, den. 6.

pro uno mantegheto[2] causa accendendi ignem pro faciendo trahere bombardas .....sol. 8.

pro una cirnileia[3] ferri causa fortandi ignem pro faciendo trahere bombardas .....sol. 6.

pro une martello, et uno pari tanagliarum ferri pro carigiando[4] bombardas .....lib. 2.

pro 9 palottis bombardarum pondere 33 libr. ad rat. 2 sol. pro libra..... lib. 3, sol. 4."

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Die 15 Sept.

"nuntio misso de Cesena Sanctum Archangelum cum lris directis vicario S. Archangeli pro parte Ser Baschi ut faceret fieri *de bombardis*.....sol. x.

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vicario S. Archangeli super facto bombardarum, quæ fiebant ibi."

From these accounts we gather that nine shot together weighed 33 lb.[5] the average weight of each shot being thus $2\frac{2}{3}$ lb. The price of 2*s.* per lb. is far beyond that of iron or lead, and corresponds with that of copper or bronze, of which we may reasonably suppose the shot were made. Saltpetre cost 6*s.* 3*d.* per lb. and sulphur 3*s.* per lb.[6] This, would make the price of a pound of gunpowder about 4*s.* 4*d.*, supposing the proportions to be three parts saltpetre to one part sulphur and one part charcoal, as already described elsewhere. The stores include linen sacks to hold the powder, and the invariable bellows and hammer. On this occasion a pair of tongs is added, and the charcoal-pan is absent; possibly the *cirnileia* may have something to do with this.

Matteo Griffone[7] tells us that a Bolognese youth was struck and killed by means of a bombard of the enemy, at Casalecchio in 1360; and Azario,[8] speaking of the attack on the same place, says that the Bolognese assaulted it with innumerable ladders, "*sclopos,* uncinos ferreos, balistas &c. &c."

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[1] Fantuzzi, Monumenti Ravennati, Venezia, 1803, Vol. V. p. 412.

[2] *Manticetto, mantaco, mantachetto,* a pair of bellows.

[3] To this word no clue can be obtained; probably it is wrongly copied from the MS.

[4] *Carigare,* onerare, charger, (Ducange). We have already seen the use of the hammer in loading.

[5] 33 lb. was the total weight of nine shot. They were clearly not 33 lb. each, as erroneously stated in the Etudes, Vol. II. p. 62. At Vol. III. p. 92, however, the weight is correctly given.

[6] In the following year the price of sulphur was reduced to $14\frac{1}{2}$ den. per lb.

[7] Muratori, Rerum Italicarum Scriptores, Tom. 18, col. 176. [8] Ibid. Tom. 15, col. 387.

This word "*sclopus*" appears to designate a smaller description of gun; and as such will be further noticed in another place.[1]

While in France we find no trace of any but very small cannon until the year 1375, and in England not until 1378, the chronicles of Pisa inform us of a bombard employed in 1362 which weighed more than 2000 lb. The Pisans were besieging the castle of Pietra Buona, within which "v'era uno, che gettava la bombarda molto a fila, et era la bombarda più di due mille libbre, e fece molto danno, che uccise piu uomini."[2]

From this date onwards we meet with constant mention of the employment of, and effects produced by bombards. A few instances only will be given, selected from those contemporary chroniclers who are considered by Muratori as veracious, and also as having written from personal acquaintance with, or careful enquiry into the facts which they relate.

Filippo Villani says that he was present in 1363, when the Council of Florence were advised by some who distrusted their captain, Pandulph Malatesta, to put the palace into a state of defence, and "di mettere le balestre grosse, e le bombarde in punto."[3]

The chronicles of Pisa relate that in 1364, the Pisan army went to the gates of Pistoja, and there "gittonvi le bombarde e molte quadrella."[4] This is confirmed by Neri Donato, who also tells us that in the same year the men of Pisa came to the gates of Pescia, and those within cast from bombards "molte *pietre,* e quadrella, e lance."[5] We have here the first positive mention of stone shot in Italy.

The chronicles above named state that there were in 1370 on the walls of Pisa "di buoni balestrieri, e di molte bombarde," and the besiegers, when they perceived these bombards, ran away, and dispersed over the country in their fear.[6]

Galeazzo and Andrea Gataro assert that in October, 1372, Taddeo Giustiniano, the purveyor of stores to the Venetians in their camp, "si messe in ordine con edificii e bombarde," and that in November of the same year, the podestà and captain of Chioggia and others used bombards against a fort belonging to Padua.[7] Galeazzo Gataro goes on to relate that the captain of the Paduan army sent to Padua for

"bombarde infinite, le quali vennero di presente, e tutte quelle, dove erano di necessità, furono discaricate, et ora nel campo de' Veneziani gittate: per la qual cosa con gravi lor danni, e con moltitudine di morti e feriti in quantità, convenne loro ritirarsi in disparte; e fu li' ferito Messer Federico Todesco lor Marescalo di una bombarda, per modo che poco passato gli convenne morire."[8]

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[1] For further information on the subject of this word the reader may consult Omodei. Dell' origine della polvera da Guerra, cap. 5, pp. 38–40.

[2] Cronica di Pisa, Muratori, Tom. 15, col. 1037. These chronicles, though anonymous, were evidently written about the end of the 14th century.

[3] Muratori, Rer. Ital. Script. Tom. 14, col. 740.

[4] Ibid. Tom. 15, col. 1042.

[5] Ibid. Tom. 15, col. 182.

[6] Ibid. Tom. 15, col. 1058.

[7] Ibid. Tom. 17, col. 104 and 107. Galeazzo died in 1405, and his son Andrea continued and completed his chronicle.

[8] Ibid. Tom. 17, col. 111.

The same authors mention the employment of bombards both in the attack upon Curan by the Venetians, and its defence in the same year.[1]

It appears by the Neapolitan journals that Queen Joanna besieging Teano in 1373, made use of "trabucchi, bombarde, e cave da ogni banda."[2]

In the same year the Paduans and Venetians again employed bombards against each other "che dall' una parte e dall' altra era tanto rumore, che non s'intendava persona nissuna." Many were wounded and killed on both sides, among the latter being Count Richard of St Boniface; and again shortly afterwards the fire of the Venetian bombards compelled the Paduans to retire with great loss.[3]

We learn from the Milanese annals, and the statement is confirmed by Mussi in the chronicle of Piacentino, that in 1373, Galeazzo Visconti employed bombards, in conjunction with other engines, in the siege of Vercelli with very great success.[4]

Daniello Chinazzo, in his relation of the invasion of the Venetian territory by the Duke of Austria in 1376, mentions that

"Quelli di Feltre, e di Cividal, intesa la partita de Veneziani da Quero, mandarono due bombarde, una sul monte di Corveta, l'altra su la strada appresso la Chiusa vecchia, chiamata la Moschetta,"

and that shortly afterwards Cavalli, the Venetian captain, retook the two "bastie di Quero per forza di bombarde," and having taken up a position before Feltre, "cominciò a bombardar la città."[5] This is corroborated by Andrea Gataro, who further tells us that the Genoese assaulted Tenedo, when by both them and the Venetians many bombards were employed.[6]

In 1378 the war between Venice and Padua was renewed, and affords a curious instance of bombards taken to the top of a steeple or belfry and fired from that position. Chinazzo relates that the captain of Padua "mise campo a Mestre, e combattè la bastia, ed il borgo di S. Lorenzo con gran gente.....la circondò da tutti i lati, battendola con bombarde e mangani." .....And when he had obtained possession of the suburb he "messero alcune bombarde sul Campanil di S. Lorenzo, colle quali facevano dentro della Terra grandissimo danno."[7]

Galeazzo and Andrea Gataro confirm these statements of the great value of the bombards in this attack.[8]

We read in the chronicle of Rimini that, in this same year 1378, Galeotto, besieging Cesena, made use of "cinque trabucchi, e bombarde, e balestre infinite, che dì e notte non finivano;"[9] and the Venetians, according to

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[1] Muratori, Rer. Ital. Script. Tom. 17, col. 121-122.

[2] Ibid. Tom. 21, col. 1036. This appears to disprove the assertion of Sismondi (Hist. des répub. Ital. du moyen âge. Paris, 1826, Vol. VII. chap. 52, p. 249), that when Urban VI. was besieged in the castle of Nocera, artillery had not as yet been introduced into the kingdom of Naples.

[3] Ibid. Tom. 17, col. 185—186.

[4] Ibid. Tom. 16, col. 752 and col 515.

[5] Ibid. Tom. 15, col. 709 and 710.

[6] Ibid. Tom. 17, col. 225, 226. See also further on, p. 32.

[7] Ibid. Tom. 15, col. 714.

[8] Ibid. Tom. 17, col. 251

[9] Ibid. Tom. 15, col. 921.

Sanuto, bombarded the Austrian port of Zara,[1] and, according to Chinazzo, took Cataro by means of bombards in the same year.[2]

Innumerable other instances of the employment of bombards in the attack and defence might be cited, but it would be to little purpose; for enough has been said to shew that they were in common use throughout Italy at this period, each state from north to south constantly making war on its neighbours, and thus requiring a powerful armament of these comparatively new, but invaluable weapons. But it is impossible to pass over without notice the famous war of Chioggia between the Venetians and Genoese in 1379-80, in which the bombards played so important a part. The story of this war is told by many authors, but we rely most upon the chronicles of Daniello Chinazzo, and Andrea Gataro, and especially those of the latter author. He informs us that the Venetians, to close the port of Chioggia, placed in the middle of the canal a vessel (*cocca*) well supplied with bombards, and the Genoese planted many great bombards on the bank, and fired at the vessel, which the Venetians were constrained to abandon. They retired to S. Domenico, and commenced to arm three barques (*barconi*) with bombards. A battle was fought on the bridge near Chioggia, and bombards were employed both by the Venetians and the Genoese, whose captain, Pietro Doria, sent some of his galleys to aid in the fight. Finally the Genoese took Chioggia, and there placed "molte barche armate con balestrieri assai e bombarde;" and the Venetians, in abandoning their position at Malamocco, first withdrew their bombards.

But while affairs were proceeding so prosperously for the Genoese, the Venetian populace, in despair at the result of the late actions, raised a tumult, and called loudly on the government to liberate Vettore Pisani, who had been imprisoned on account of his losing the action of Pola. The government set him at liberty, and created him, at the people's demand, naval commander-in-chief; when at once fortune turned in favour of the Venetians; for Pisani, in no way resenting the severity with which he had been treated, but animated by a pure spirit of patriotism, so greatly encouraged all by his counsel and his actions, that the Genoese, hitherto conquerors, soon became the vanquished in the war.

The Paduans and Genoese now used every effort to protect themselves from attack: they constructed a work at Malamocco, and armed it with "grosse bombarde, e con altre bombarde." They had galleys in the canal furnished with bombards, to attack which the Venetians sent a number of small boats, "et ogni barchetta aveva una bombarda in proda," and they fired at the Genoese, doing them much harm. Pisani sent to Treviso for all sorts of weapons, including bombards, and on every occasion where there was any fighting, there we hear of the bombards making such a noise that it seemed "che il mondo venisse in terra" or "volesse finire."

Early in January 1380, the Venetians retook Loredo, and Torre Nuova, by means of two great bombards; of which "una tirava pietre di libre 195, l'altra di libre 140; et una era nominata la Trivisana, l'altra la Veneziana."[3] Pisani established these guns in battery on the bank, and proceeded to

[1] Muratori, Rer. Ital. Script. Tom. 22, col. 681.

[2] Ibid. Tom. 15, col. 716.

[3] According to Chinazzo, this was called "Vittoria."

bombard Brondolo. On the 22nd January the great bombard was fired, and it struck the Campanile of Brondolo, knocking down a great piece of the wall, the stones of which struck and killed Pietro Doria the Genoese general, and his nephew, whose bodies, with many tears and great grief on the part of the Genoese, were taken to Chioggia, and embalmed (*salati*) for removal to Genoa.

On the 23rd, the same bombard knocked down a great piece of the wall of the same Campanile, and killed 22 men. The Venetians made it a custom to discharge these bombards and the mangonels in the evening, and they were fired in the morning at daybreak against the monastery; and the Venetians continued to fire these two great bombards till a large part of the monastery was in ruins, and a considerable number of the men who were in it were killed.[1]

By such means did the Venetians recover their losses, and defeat the Genoese. Perhaps of all the notices of early cannon which have been presented to us, this is the most remarkable. On board boats, in action on shore, in attack and in defence, on every occasion of a fight, the bombards were scattering death among the combatants. And in Italy, as in all the other countries which we have noticed, great stone shot and great cannon were introduced together. Although the Italians had used both iron and brazen projectiles, these had probably never reached any great size, but the huge stone shot had indeed terrible effect.

An inventory taken at Bologna in the year 1381, and published in full in the Emperor Napoleon's Etudes,[2] contains the following items relating to our subject:—

In primis in cortile.

Ducentos nonaginta quinque lapides a bombardis.
Lapides marmoreos a bombardis trecentos triginta quatuor.

In secunda camera.

Quatuor canones a bombardis inter quorum unus est cupri sine cepo, et alii cum cipis ferratis.
Duos carrittos a bombardis cum duabus rotis pro qualibet.
Unam scannum a bombardis cum uno police.
Unum canonem cupri a bombardis ponderis librarum CCCLXI.

In prima camera ferramentorum.

Centum septuaginta cocones lignei a bombardis.

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[1] The descriptions given by And. Gataro and Chinazzo agree in all material facts. A portion of the text of the latter is printed below. "Alli 22, nel Campo da Fosson fu scaricata la bombarda grossa, la qual diede nel Campanile di Brondolo e gettò giù in terra un gran pezzo di muro, le pietre del quale percossero, & ammazzarono il Doria generale de' Genovesi, & un suo nipoti, i quali con grandissimi pianti, e con dolor universale de' Genovesi furono portati in Chioza grande, e salati per portare a Genova. Et alli 23, l'istessa bombarda gettò giù un gran pezzo di muro in detto Campanile, che ammazzò altri 22 huomini. Et era solito de' Veneziani caricar le bombarde la sera, e così i mangani, e nell' Alba gli scaricavano contra il detto Monastero; e continuandosi a scaricar le due Bombarde grosse soprascritte, gran parte di esso Monastero si spianava, & assai huomini di quelli di dentro restavano morti."

[2] Vol. I. p. 358.

In camera a bombardis.

Quinquaginta quatuor balotas ferri a bombardis lib. CCCLXXIIII.
Sedecim balotas ferri a bombardis ponderis lib. CCC.
Trecentos octuaginta quinque balotas parvas ferri a bombardis ponderis lib. CCXXXV.
Centum triginta tres balotas ferri a bombardis ponderis lib. LXVI.
Ducentas sexaginta duas balotas ferri a bombardis ponderis lib. LXXXXII.
Sexaginta balotas ferri a bombardis ponderis lib. XLVI.
Unum barillem novum sal nitri ponderis lib. ducentas sexaginta sex.
Decem et octo balotas ferri a bombardis pond. lib. sex.
Unam botexellam pulveris a bombardis ponderis lib. centum sexaginta tres.
Unam botexellam pulveris a bombardis non bona ponderis lib. LXXVII.
Tres pallos ferri } ponderis lib. CLXXXI.
Duo scrocatoria }
Novem scrocatoria ferri a bombardis.
Quatuordecim tassatoria ferri ponderis lib. trigenta novem.
Undecim teleria a bombardis veteres et inutiles.
Quatuordecim bombardas novas fulcitas corigiis teleriis et canonibus.
Quatuor bombardas veteres fulcitas congiis teleriis et canonibus.
Unam bombardam cum uno canone cupri.
Novem bombardas a scaramosando.
Duas bombardas una cum manico ferri, alia sine.
Unam botexellam pulveris ponderis lib. CXLVIII.
Buttighinum parvum cum sulfano integro ponderis lib. decem et octo et demidio.
Unum taschitum pellis cum pulveris ponderis lib. 7, onc. 7.
Unum taschitum plenum sulfani pistati pond. lib. 4.
Tres telerios novos non fulcitos a bombardis.

Camera a capistris, et a taglis.

Quadraginta duos cocones magnos ligni a bombardis.
Centum quatuordecim cocones parvos a bombardis.

Camera a balistis.

Sex mantighellos veteres et destructos ad soflandum in bombardis.
Duos buffitos novos a bombardis in una cassa.

This inventory is worthy of analysis. Let us first consider the bombards themselves. We find 14 new bombards, furnished "corigiis, teleriis, et canonibus," 4 old bombards furnished "corigiis,[1] teleriis, et canonibus." Then there are one bombard with a copper cannon, nine bombards for skirmishing, evidently very small or hand-guns, and two bombards, one with an iron handle, and one without. The *corigia*[2] were the iron bands used to fasten down the bombard to its *telerium* or support. The *teleria* were clearly and unmistakeably the beds or supports in which the bombards were placed, and not, as some antiquaries think, handles for the guns. In this inventory we find them separate from the bombards, eleven worn out and useless, and

[1] Napoleon in this place reads "congiis teleriis," and translates it "affuts courbés." This is clearly an error.

[2] *Collistrigium*, a yoke for oxen from "*collum-stringo*:" or *corigium*, a binder, from *colligo*;

three new not attached to bombards.[1] The *canones* were the chambers for the bombards, in some cases, if not in all, distinct and separate from the bombards, though attached before firing; it is not improbable that they could be used independently of the bombards, if necessary. They are found not only with the bombards, as above, but in separate items of the account we meet with four, one of copper without a *cepus*, three with iron *cippi*; and another of copper weighing 361 lb.

These *cepi* or *cippi*[2] were probably blocks of wood, stocks in which the *canones* were placed when used separately from the bombards. They are again mentioned in an inventory of a later date, as used with bombards, and we will notice them again in that place. The *cocones*, of which there were 326 of different sizes, were the wooden plugs used to close the breech ends of the *canones*, after the latter were loaded; and a new plug was required after each discharge.

The whole operation of loading, and the form of the bombard and cannon are described in plain language by Andrea Redusio. This author in the "Chronicon Tarvisinum," writing of that which had come to his own knowledge during his lifetime, and describing the attack of the Venetian army on Quero in 1376, speaks as follows:—"After the occurrence of these events, the army of the Venetians passed by Quero and manfully attacked both forts, by means of bombards, which had never before been seen or heard in Italy, but which the Venetians had caused to be constructed in a most wonderful manner. The bombard is an iron instrument, of great strength, with a wide tube (*trumba*) in front, in which is a round stone of the size of the tube; and it has a cannon (*cannonem*) joined to it at its rear end, twice as long as the tube, but narrower, in which a black powder, made of saltpetre, sulphur, and willow charcoal, is inserted through the opening (*foramen*) of the cannon towards its mouth (*buccam*). This opening is then closed with a wooden plug which is pressed in; and when the round stone has been inserted and adjusted against the mouth of the cannon, fire is applied through a smaller opening in the cannon, and the stone is projected with great impetus by the force of the lighted powder; nor can any walls, no matter how strong, withstand it, as was found out by experience in the following wars. And when these bombards thus belched forth stones, the people thought that God was thundering from above."[3]

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[1] A later inventory (1397) will shew even more distinctly what these *teleria* were, see p. 35.

[2] *Cippus*. The rough stem of a tree, a horse block, &c.

[3] "Quibus sic peractis exercitus Venetorum Querum pertransit, et ambas bastitas viriliter impugnat, vi tamen bombardarum, quæ ante in Italia nunquam visæ nec auditæ fuerant, quas Veneti mirabiliter fabricari fecerunt. Est enim bombarda instrumentum ferreum fortissimum cum trumba anteriore lata, in qua lapis rotundus ad formam trumbæ imponitur habens cannonem a parte posteriori secum conjungentem longum bis tanto quanto trumba, sed exiliorem, in quo imponitur pulvis niger artificiatus cum salmitrio et sulphure, et ex carbonibus salicis, per foramen cannonis prædicti versùs buccam. Et obtuso foramine illo cum concono uno ligneo intra calcato, et lapide rotundo prædictæ buccæ imposito et assentato, ignis immittitur per foramen minus cannonis, et vi pulveris accensi magno cum impetu lapis emittitur. Nec obstant muri aliqui, quantumcumque grossi. Quod tamdem experientia compertum est in guerris quæ sequuntur. Quibus quidem bombardis tunc lapides eructantibus homines putabant desuper Deum tonare."—Muratori, Rer. Ital. Script. Tom. 19, p. 754.

The stores specified as being for the service of the bombards included nine *scrocatoria* of iron, fourteen *tassatoria* of iron, and one *scannum cum uno police*. What the *scrocatoria*[1] were we are unable to assert. Technical terms such as this are little noticed by the glossarists, and unless we can trace the origin of the word which it is sought to interpret, or can gain from the context some clue to its meaning, we must remain in doubt. The *tassatoria* were scoops or ladles for inserting the powder into the chamber; but this will appear more plainly from the evidence of a later inventory, which will shortly be quoted. Bellows, as usual, occur in the list of stores, and the hot iron was doubtless employed to fire the charge. Two carriages, each with two wheels, are mentioned; and, when we come to a later period, we shall be able to judge from the miniatures of contemporary MSS. of what nature they were.

Iron shot, 928 in number, of which 385 were small, appear in the "bombard-chamber;" and 620 stone shot, of which 334 were of marble, in the court-yard. Of good powder in casks, sacks, or bags, there were 318 lb. 7 oz.: and of bad powder 77 lb. 266 lb. of new saltpetre, 18½ lb. of whole sulphur, and 4 lb. of powdered sulphur were ready for the manufacture of more powder, when required.[2] Some of the shot are indicated as being so small that the bombards from which they were fired can have been no larger than hand guns.

Of such a nature as this, and very different from the great bombards with *canones* joined to them to hold the powder, must have been those which Andrea Gataro mentions as placed in three rows, 48 bombards in each row, that is to say, 144 bombards in all, on one carriage.

He tells us how Antonio della Scala (Scaligero), being anxious to defeat the people of Carrara,

"prima fece comandare tutte le genti del suo paese, che potevano portare armi, che subito possero a Verona; depoi ordinò tre carrette armate a tre solari, e per cadaun quadro di solaro pose dodici bombardelle, che portavano palle di grossezza d'un 'uovo, che erano in numero 144 per cadauna carretta, con tre persone ancora per cadauna che avessero da tirare le dette bombardelle; et erano ordinate in modo, che di dodici in dodici si dava loro fuoco, e dovevano trarre tre fiate alla volta, una per cadauna carretta, che erano 36. al tratto, e ciò doveva essere allora, che si toglieva la battaglia contro le schiere Carraresi per rompere loro l'ordine.

Erano le carrette menate da 4. cavalli grossi, coperti d'arme per cadauna, con un' huomo armato con un' azza in mano per cadauno cavallo."[3]

Here we have on one carriage 144 bombards, each throwing a ball as large as an egg, managed by three men only, that is, forty-eight bombards by one man. Their small size is marked by the word *bombardelle* which is employed instead of *bombarde*. They were so arranged as to give their fire by twelve at a time, and the three rows could be fired at once, so as to

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[1] Query? *Crochus*, a hook.

[2] There are other very interesting items in this inventory: rockets winged with pasteboard, arrows called *muschitæ*, &c.; but as they do not belong to the subject of cannon, they are not discussed here.

[3] Muratori, Rer. Ital. Script. Vol. XVII. col. 558; and see Giovanni Citadella, Istoria della dominazione Carrarese in Padova, Vol. II. p. 60.

discharge 36 balls together. Each carriage was drawn by four horses, with an armed man on each horse. This corresponds with the *orgues* which are found figured in books of a later date.

Another inventory taken at Bologna in the year 1397,[1] must close the list of notices of Italian cannon during this half century. The items which relate to the service of cannon are as follows:

In stantia curtilis in domo inferiori et terrena.

In primis XII bombardas a secchia, deficiunt duo corigie de ferro, et sex caviclas de ferro, et quinque bletas de ferro de quibus due sunt magagnatæ et fractæ.
Unam bombardam saldam.
Duas bombardas cum Zippis saldas.
XVII bombardas cum secchis, deficiunt XI bletæ de ferro et duas caviclas.
VIII bombardas, deficiunt sex caviclæ de ferro, et quinque blette de ferro, et unum cippum magnum de ligno.
Unam cippum a bombarda cum corigiis de ferro.
Unam bombardam pizolam cum manico fracto.
Septem bombardas cum teleriis.
Unam bombardam pizolam cum lapide et cippo.
Quatuor sclopos pizolos in uno telerio.
XXXIII sclopos cum cippis.
Septem sclopos sine teleriis.
Unum sclopum parvum a cavalito et sine cavalito.
Unum sclopum cum telerio.
Unum sclopum de ferro cum cippo.
VIII sclopos de ferro de quibus sunt tres a manibus.
Unum telerium cum duobus canonis.
Unum telerium cum duobus sclopis.
Unum canonem ad modum bombarde sine telerio.
Duas bombardas cum teleriis a ballotis de lapidibus.
Tres salvavinellos ad implendum bombardas.

In camera ferramentorum.

Duodecim tassatorios de ferro a bombardis de quibus decem sunt ponderis lib. trecentarum septuaginta quinque de quibus unum fractum.
Decem et septem tassatorios de ligno.
Unum tassatorium de ferro parvum.
Septem tassatorios de ferro ponderis librarum viginti.
Septem tassatorios de ferro cum manico de ligno a sclopis.
Quatuor bletas pizolas de ferro a bombardis.

Camera a balistis.

Sexaginta quinque libras de ferro a bombardis videlicet ballottas.
Septingentas quinquaginta ballottas de ferro a bombardis.
Unam cazolam de ferro causa carigandi bombardas.
Duo millia ducentos viginti ballottas de lapide a bombarda.
Unam bombardam pouderis librarum ducentarum septuaginta trium.
Unum palum de ferro sive tassatorium.

[1] Published entire in the Etudes. Vol. I. p. 363.

The details and names of the stores in this list vary somewhat from those in the inventory of 1381. There are here *bombardæ, canones,* and *sclopi;* the first being the larger, and the two latter the smaller pieces. Of the bombards, thirty-seven are described as *a secchia,*[1] or *cum secchis,* that is to say, with chambers like pails or pots; three others in good condition, two of which have *cippi;* nine with *teleria,* two of which are for stone shot; two small bombards, one having a broken handle, and the other having a *cippus;* and finally, in the crossbow chamber, one bombard weighing 273 lb.

Of the *sclopi* there were four small in one *telerium;* again two small in one *telerium;* thirty-five with *cippi;* one with and seven without *teleria;* eight others of iron, three of which were for the hand; and one small *sclopus a cavalito et sine cavalito,* i.e. to be mounted on a stand (*chevalet*), but without its stand. The *sclopi* were small guns, but wherein they differed from the bombards we have at present no means of judging.

There were but three *canones,* two of which were in one *telerium,* and one was like a bombard without a *telerium.* These cannon were evidently used independently of the bombards; and the word *secchiæ* seems to have taken the place of *canones* as chambers for bombards.

These items explain almost beyond the possibility of further doubt both the *cippum* and the *telerium.* In an item of eight large bombards there is missing one large *cippum* of wood; and the very next item is, one *cippum* for a bombard with binders (*corigie*) of iron. Both bombardæ and sclopi are furnished with *cippi,* or with *teleria,* but in no single instance do they both occur together. They were evidently both wooden supports, stocks, or beds, for the guns, but there was some technical difference between them, which we are unable to discover. One item here, viz.: *four small sclopi in one telerium,* ought to set at rest for ever any doubt on the subject of the *telerium;* for how could four guns be *in uno telerio,* if the telerium were the handle or tail of a gun? What the handle was called we see in the "bombarda cum *manico* fracto."

The *corigie,* or iron bands, passing over the bombard, and holding it down on its bed, again occur in this inventory; and we meet with iron *caviclæ* and *bletæ.* The *caviclæ* are no doubt pins or bolts to fasten down the *corigie,* and correspond to the *chevilles,* so often already met with in French documents. The *bletæ* we have been unable to trace. They were probably some small iron nails, pins, or washers, but the word is not to be met with in any glossary.

The stores include "*salvavinelli*"[2] for filling the bombards. These were small measures or cups, and served the same purpose as the *cazola*[3] of iron for loading the bombards; probably to take the powder from the barrels or bags, or to pour it into the gun when the *tassatoria* were not used.

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[1] *Secchio,* a pail, pot, &c. The word *pot* is reproduced in various languages. At Rouen in 1338, we met with a "*pot de fer;*" in an English inventory (1372–4) occur guns with *pootz* or *pots.* Indeed, bearing this in mind, it is a matter for consideration whether we *must* refer the word *cannon* to *canna* a reed, when we have the English *can,* Fr. *canne,* Flem. *kann,* Germ. *kanne,* each signifying a pot or measure to hold liquor, and when we compare the remarkable similarity of form between a drinking mug, and the chamber with a handle of some of the early cannon.

[2] *Salvia,* a measure of wine. Ducange, *Salvare vinum.*

[3] *Cazola, cassola,* a measure. Ducange,.

The *tassatorium*,[1] or as it is also called in the last item *palum*, was a scoop or ladle at the end of a long handle, used for loading with powder. It was of wood, or of iron with a wooden handle.

There were 750 iron round shot, 2220 stone shot, and 65 lb. iron for making shot.

Thus in Italy, as we have seen elsewhere, the small cannon and the large bombard with stone projectiles were employed side by side. Italy, always a step in advance of other nations in artillery, was in possession of the stone-projecting bombards some years earlier than the other countries which we have considered; and also enjoyed the advantage of iron shot in place of leaden ones. In all these Italian documents we have no mention of lead as a material for shot. Doubtless the superiority of the iron from its greater hardness was found out at an early date in Italy, and as it also combined the advantage of cheapness, it was invariably preferred for the smaller natures of guns.

We have now traced, as proposed, the history of cannon through the second half of the fourteenth century, in France, Belgium, England, and Italy. Let us state in a few words the conclusions to which we are led. Cannon of iron and bronze under the various names of *guns, bombards, cannon, sclopi,* or *schioppi,* are found bound down to large heavy wooden beds, and employed in sieges both for attack and defence throughout the whole period. Projectiles of lead, stone, and in Italy, iron, and even bronze, were thrown by them; also arrows, and Greek fire. But it appears, from the length of time which sieges lasted, that the art of opening a practicable breach by means of cannon had not yet been invented. Indeed, it is very doubtful whether with such powder sufficient force could have been obtained for that purpose. This powder was still a comparatively feeble agent. The ingredients pounded by hand in a mortar, were themselves but imperfectly purified, and when reduced to a state of fine powder, the gas must have passed very slowly through the mixture, and an immense quantity of the charge must have been blown out without being ignited. To prevent excessive windage, the leaden shot were driven forcibly home into the bore of the piece by means of a mallet and drift, (*drivel, cache, poussoir,*) and the soft nature of the metal allowed them completely to fill the bore. With iron and stone shot fired from the large guns, no drift was used, but the shot was inserted from the muzzle, and the powder by a scoop from the breech, which was then closed by a wooden tompion. The hot iron was still used to fire the charge through a vent, which was often covered to keep the powder dry. But rough as these appliances were, we must not despise too much the cannon of the fourteenth century. They were suited to the age. To knock down such a piece of wall as to kill twenty-two men at once, is a feat which is not easy even in these days; and it is interesting to consider how the very defects were suited to each other. With the appliances for forging and welding iron so imperfect as they were, what would have been

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[1] *Palus*, Bas. Lat. *pelle*, Fr. (Ducange). *Paele, pelle*, (Roquefort). Lat. *patella*. Ital. *Pala*. Any broad flat shovel or scoop, a baker's peel (Florio).

Tassa. schyphus, patera. Fr. *Tasse*, (Ducange). *Schyphus*, a scoop.

the use of granulated powder? No gun then made could have withstood the force of a large charge—and, bearing in mind the rapid increase of strain as compared to the increase of calibre, no large projectile could have been fired. Small projectiles, no matter what their velocity, would never have had the moral effect of those huge masses of stone from 200 lb. to 450 lb. in weight, crushing and annihilating everything except thick masonry. Again, had the art of constructing first rate guns been developed, what would have been gained where the powder was so weak as not to require them? We shall find, as we proceed in our enquiry, how the attack was made to keep pace with, or rather to overtake the systems of defence, which were altered to resist the force of the guns brought against them.

In the field, cannon had as yet made but small progress. Cumbrous, slowly loaded, and very costly both to manufacture and to transport; their effects were not to be compared with those produced by the longbow with its rapid delivery of a shower of arrows. Hand guns were invented, but were rude and clumsy in form; and scarcely to be distinguished from the small cannon, which in one instance, were mounted to the number of 144 on one carriage, and oftener two, three, or four on a small two-wheeled carriage, for service in the field.

Thus far we have had to trust to verbal description alone, but in the next paper we shall enter upon a period where we have not only the artists of the fifteenth century to portray for us varieties of form and material, but some of the very pieces of ordnance which were actually employed.

METHOD OF MEASURING DISTANCES OF SHIPS FROM COAST BATTERIES BY MEANS OF THE ELECTRIC TELEGRAPH.

[COMMUNICATED BY CAPTAIN R. W. HAIG, R.A.]

The following account of Mr Madsen's telegraphic method of measuring distances of ships from coast batteries by means of the electric telegraph is translated almost literally from that gentleman's address to the Danish government, and is the more interesting as describing a method which has actually been adopted and is now in use at Copenhagen.

The value of such a system must be estimated in a great measure by its practicability, and when it is remarked that by its means the positions of a ship in motion can be readily determined at successive intervals of one minute, and that the *employés* are regularly practised in doing this, the reader can scarcely fail to be of opinion that Mr Madsen has well earned the Order of the Danebrog, which has been conferred upon him by the King of Denmark, in consequence of the success of his endeavours and experiments.

COPENHAGEN,
15th March, 1865.

"In forwarding to the Government the accompanying work, entitled 'Scheme of a telegraphic method of measuring distances for artillery purposes,' I have the honour to point out that my system has been approved by the Minister of War and adopted in the maritime fortifications of Copenhagen where it was used with complete success during the war of 1864."

I will now confine myself to giving a short description of the telegraphic arrangement for fortifications, and of the manner in which the measurement of distances has been effected.

Telegraph.

As will be seen by the plan, the maritime forts and the principal station of "Quintus" are connected together by a submarine cable of four strands, which extends from "Trekroner" to "Prövesteen," passing through "Lynetten," "Quintus," and "Mellemfort."

Two other cables, starting from "Quintus," go one to the coast batteries "Huth" and "Ny Kalkbrænderi" to the north, and the second to Battery "Stricker" to the south, and this latter cable then goes on to the pilot station "Dragor," where a post has been established for observing the Gulf of Kjoge and quarter to the south.

Finally, Elsinore, where there is a similar look-out station, is in telegraphic communication with "Quintus."

All the telegraphic cables are thus united at "Quintus," and by this arrangement, and by making all the stations intermediary, telegrams sent from

Lithographed at the Royal Artillery Institution

any point pass through the whole circuit in such a manner that "Quintus" communicates, simultaneously with all the forts and batteries, and the messages exchanged among any of them pass at the same time through all the other stations.

A special apparatus established at "Quintus" affords the means of separating the stations into several independent groups all however communicating with the principal station, an arrangement which would be very useful in the case for example of a combined attack on both north and south forts, for "Quintus" could then correspond at the same moment with the northern group ("Huth," "Ny Kalkbrænderi") the southern ("Prövesteen," "Mellemfort," "Stricker"), and besides with the principal forts of ("Trekroner, "Lynetten," and "Prövesteen,") which are for this purpose provided each with two sets of receiving apparatus.

The telegraph apparatus employed at each station is the Morse receiver without relays, recording in ink, and made by Digney Brothers and Co., Paris.

The galvanic batteries are as weak as possible, being composed of only 12 cells, so that the resistance to the electro-magnets, as I am assured by direct experiment, is only one-seventh of the ordinary resistance, or about 200 units of Sieman's scale for each receiver.

The operators were young soldiers selected for the purpose, who during the establishment of the telegraphic communication were thoroughly instructed in all telegraphic operations.

Measurement of Distances.

On each fort or battery there is a covered observatory in such a position as to command a good view of the horizon, and when its distance from the telegraphic operator is great enough to render it necessary, means of instant communication are afforded by an acoustic tube. The measurement of angles from the observatory is effected by a theodolite the telescope of which is short and field of vision large. The horizontal circle is provided with a vernier, which allows of angles to every 5′ being read off easily and quickly.

According to my original plan, the measurement of distances was to have been effected by means of tables giving the distances corresponding to observed angles. But during the preliminary labours of the commission, the chief engineer Major Ernst, proposed a graphical method which he considered would afford results of sufficient accuracy for artillery purposes provided that the maps or charts employed were on a sufficiently large scale, and this idea having been approved, each station was provided instead of tables with a chart embracing a distance from the fortifications of about $\frac{3}{4}$ths of a mile (6 kilometres). These charts are on a scale of $\frac{1}{10000}$ and are spread each upon a table. Upon each of the forts and batteries indicated on the charts, and in a position corresponding exactly to the centre of each theodolite a small brass circle is fixed carrying a very fine black thread and surrounded by a concentric exterior circle, divided into degrees and twelfths of degrees, the zero point of which is in the north.

Before commencing observations all the theodolites as well as the divided circles on the charts are adjusted, so that the zero points may all be exactly in the north.

The manner of operating is then shortly as follows:—

A fort points out an object, and makes known its position by telegraph.

The principal station details the two forts that are to observe and also the one that is to direct and indicate the moment of observation in the case of the object being moveable. The observers announce when they have found the object, point at it, and read the angles to the telegraph operators who transmit them to the other stations, when by means of the threads and divided circles they are laid down upon the charts.

A point of intersection is thus obtained, which represents the position of the ship or object at the moment of observation, and after having marked this point in pencil, its distance from the fort or battery is measured by a divided scale, graduated so that distances of 25 feet can be read off with facility.

At the fort "Prövesteen" the distance thus found is communicated to the casemate battery by means of an acoustic tube.

In the regulations, of which a copy is appended, are collected all the details relative to the measure of distances both of fixed and moveable objects which accord with those given by me in the original scheme.

These regulations are based upon the results of daily experiments carried on throughout the summer of 1864, which succeeded so well that the distances of moveable objects were determined with great precision with only half minute intervals between the observations. Such observations are now directed to be made at intervals of one minute, in order that the observers may work with greater certainty.

The trials above alluded to were principally made upon the numerous steam boats passing in sight of the fortfications, whose tracks were marked out upon the charts.

In general each ship was not observed more than five times, but its course was sometimes followed for a longer time, and the operations were only suspended for a short time, when for the purpose of obtaining greater nicety in the points of intersection, one of the observing forts was replaced by another. Errors made in the measurement of angles (an advantage of the graphical method) are easily recognized by the abrupt change in direction of the ship's track.

The simultaneous observations of three forts afford a means of testing the proper adjustment of the zero points of the theodolites. Plotting the angles and measuring the distances upon the chart present no difficulties whatever.

The graphical method has also the advantage of clearly depicting the movements of a ship, and thereby exposing the reasons by which its course is governed, facts which would be of great importance when the system of defence comprises the use of submarine mines or torpedoes.

In most cases it is possible to determine with sufficient accuracy the position which a ship will occupy at a given future moment, and thereby to regulate the explosion of torpedoes laid down in its track, so as to obtain the greatest possible effects.

Another interesting application of this method is the determination during practice of the points of impact of shot fired from the various batteries.

We will give one example which happened when firing at long ranges.

The target was placed at 8200 feet from "Prövesteen," and at 10,400 feet from the "Trekroner," where after having observed and plotted upon the

charts the points of impact of the several shot, they were found to be uniformly distributed about the target with the exception of three shots from "Mellemfort," which had carried from 400 to 600 feet too far.

The directing fort "Prövesteen" having telegraphed this information to "Mellemfort" the succeeding shot struck just in front of the target.

The telegraphic method of measuring distances has therefore undergone a successful practical trial and its great importance for long range fire with modern rifled guns of large calibre is completely established.

As I have already remarked in my first work on the subject, this method can be made use of in fortifications of great extent which comprise detached forts, but it is especially applicable and capable of rendering important services in maritime fortifications.

In conclusion I will add that I am ready to supply the government with more detailed explanations and to place at its disposal the experience which I have acquired.

(Signed) C. L. MADSEN,
Inspector in the Administration of Government Telegraphs.

Chevalier du Danebrog.

Regulations for the measurement of distances, for the use of the Maritime Fortifications of Copenhagen.

1. As the exact measurement of distances requires above all things that the different telegrams should be transmitted with rapidity, certainty, and clearness, and according to a regular system, the telegraph operators are directed to conform rigidly to the following rules:—

The telegrams to be as short as possible without introducing any abbreviation, from which a misunderstanding might at any time arise.

Any correspondence between two stations must not be interrupted on any account when once begun; and the operators must exclude from their conversation all subjects foreign to the matter immediately before them.

Each station will take care to preface every communication with the mention of its name.

2. While messages are being sent, the operators will concentrate all their attention upon their apparatus, and give notice of all the information transmitted to their station.

3. At the commencement of and during each operation, those whose duty it is to observe angles, will try to distinguish as quickly as possible all the ships in sight, in order that they may be able to find easily any one of them which may be indicated. They should frequently test the zero point of the horizontal circles of their theodolites, and will keep a general look out in the mean direction of whatever ships may be in sight.

4. The principal station "Quintus" is to direct operations, and to point out what stations are to observe.

5. When an observation is to be made, "Quintus" telegraphs as follows: "Quintus. *All stations prepare to measure.*" To which all the stations reply in a given order (from north to south), "Trekroner," "Lynetten," "Mellemfort," &c. "*Ready.*" The instruments are then ready to work.

6. When the distance of a ship from a fort is required, the fort is to telegraph and give an exact description of her, stating whether she is in motion or not, and if in motion whether her course is to be followed, or her distance determined by a single observation, and to make known her nature, position (as for example, "to the north," "to the south," &c.), the course, distinctive marks (such as flag, colour, &c.), and in fact everything which can in any way assist the other stations to identify her.

The other stations then look for the ship in question, and when "Quintus" has found her, it announces,

"Quintus, *Found,*"

and then gives directions as to which two forts are to observe. (The fort from which the distance is required may take part in the observations, but in general two others will be chosen). If the object is moveable, "Quintus" at the same time indicates the directing station, by following the name of the fort by the numeral 1. The two stations which have thus been ordered to observe, then give notice as soon as they have distinguished the ship in question, as:

"Station *M* or *N*. *Found.*"

(If the fort which requires the distance takes part in the observations, the above notice from it is unnecessary).

The angles are then observed in the manner hereinafter directed, and this being done, the fort which required the distance is to announce the completion of the operation by the signal, "*Done.*"

A new measurement can then be carried on.

The principal station is to record the angles, in order that it may be able to exercise control, and this should also be done as much as possible by all the other stations.

7. The measurement of angles is to be carried on as follows, according to whether the object is fixed or moveable, and in the latter case, according to whether a single observation is to be made or the ship's course followed up by successive observations, the special case being always immediately announced in accordance with par. 6.

(*a*) *Fixed objects.*—When the two stations named by "Quintus" have telegraphed "*Found,*" they will observe the two angles, telegraph them, and the fort which required the distance will close the operation with the word "*Done.*"

(*b*) *Moveable object, single observation.*—When the two named stations have telegraphed "*Found*," the telegraph operator at the directing fort will dictate the moment of observation by calling to the observer "*Now*," at the same time pressing on his telegraph apparatus.

The operator of the other station thus warned, either by the tinkling of his apparatus, or by the mark made upon the morse fillet, will also call to his observer "*Now*."

Finally, having taken the angles and telegraphed them, the signal "*Done*" will be given as before.

(*c*) *Moveable object, successive observations.*—These observations are to be made at intervals of one minute, and the process of making each observation will be the same as that laid down in (*b*).

The directing fort is to give the signal "*Well*" after each observation, and operations are to be brought to a close as before by the signal "*Done*," which will in ordinary cases be made after the completion of five observations.

8. All telegraphic communications exchanged during the measurement of distances will be made in general by the wires 1 and 2, the whole line being in the circuit.

9. Keeping the journal.—Every fort is to record in its journal everything relative to the measurement of distances.

For fixed objects, the recorded moment of observation is to be that at which the first angle is telegraphed. If the object be moveable, the signal "*Now*" gives the moment of observation.

In cases of successive observation, it will be sufficient to record the moments of the first and last observations, with their corresponding distances.

10. Each station should have all measured distances plotted upon their chart.

11. Examples of measurements of the distances of various objects.

Qv (Quintus). All stations prepare to observe.
T.K. (Trekroner), *Ln.* (Lunette), *Mf.* (Mellemfort), &c., "Ready."

(*A*). Fixed object:—

Mf. Fixed object. Frigate E. of *Pr.* (Prövesteen). Red flag at the mizzen.
Qv. "Found."
Qv. *Mf.* and *Str.* (Stricker). "Observe."
Str. "Found."
Mf. 110° 30′.
Str. 49° 15′.
Mf. "Done."

(*B*). Moveable object, a single observation:—

T.K. Moveable object. Frigate N.E. of *T.K.* going towards the S. under steam and sail,
Qv. "Found."

Qv. *NKb.* (Ny Kalkbrænderi) 1 and *Ln.* "Observe."
NKb. "Found."
Ln. "Found."
NKb. "Now." (Here the telegraphic apparatus is also pressed down).
Ln. 31° 35′.
NKb. 76° 5′.
T.K. "Done."

(*C*). Moveable object, with successive observations :—

Pr. Moveable object to be followed up. Steamer to the S. White funnel.
Qv. "Found."
Qv. *Qv.* 1 and *Str.* "Observe."
Str. "Found."
Qv. "Now." (Here the telegraph apparatus is pressed down).
Qv. 125° 50′.
Str. 106° 35′.
Qv. "Well."
Qv. "Now." (Pressure on instrument).
Str. 102° 25′.
Qv. 123° 40′.
Qv. "Well."
Qv. "Now." (Pressure on instrument).
Str. 87° 45′.
Qv. 118° 30′.
Pr. "Done."

(Signed.) J. F. M. ERNST.
Commanding Engineer.

COPENHAGEN,
12th September, 1864.

ON THE COMPARISON OF THE ACCURACY OF GUNS IN ARTILLERY PRACTICE.*

BY PROFESSOR WILLIAM POLE, F.R.S.
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MEMBER OF THE IRON-ARMOUR PLATE COMMITTEE; AND OF THE SPECIAL COMMITTEE FOR INVESTIGATING THE COMPARATIVE MERITS OF THE ARMSTRONG AND WHITWORTH SYSTEMS OF RIFLED ARTILLERY.

1. In the first Volume (1859) of the "Occasional Papers" of the Royal Artillery Institution, there was published a paper by Captain A. Noble, "On the application of the Theory of Probabilities to Artillery Practice," the principal object of which was to point out a means of defining and comparing the accuracy of ordnance of different kinds. At that time rifled artillery was scarcely known; but the great and rapid development it has since attained, and in particular the late comparative experiments on guns of great accuracy, tried under very varying circumstances, have shewn that the problems involved in such comparisons are more intricate than was at first anticipated; and I would therefore venture to offer to the Institution a few remarks tending somewhat further to elucidate the question.

It will be well to commence with a brief statement of the system proposed by Captain Noble, and to make some allusion to the difficulties which have been thought to arise in its application.

2. The ordinary way of testing a gun for accuracy is to fire a great number of rounds from it, with its axis laid always as nearly as possible in the same direction; and carefully to register the positions of the various shot as they fall on a horizontal plane.

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* I have to acknowledge the valuable co-operation of Captain A. Noble, in the preparation of this paper.

The mode here adopted of calculating the probabilities is essentially the same as that given in Captain Noble's paper of 1859, and also in Didion's "Traité de Balistique," 1860. I believe, however, that the latter work contains, in the part here referred to, some important misprints, which, if not corrected, would lead to very serious errors in the practical use of the formulæ.

Having therefore these positions given, Captain Noble calculates the length and breadth of a certain rectangle, which may be supposed to be drawn on the ground where the shot have fallen, and denoting the space within which it is an equal chance that any shot will strike, or, which is the same thing, into which half the shot will certainly fall in a very large number of rounds. This is called the "*probable rectangle*," and it may be inferred from the paper (though it is not directly stated) that the author proposes to use the *area* of this rectangle, to express, inversely, the measure of the accuracy of the gun; so that a gun, which, fired at the same range and elevation, makes a probable rectangle of half the area, will be said to be twice as accurate, and so on.

The process by which the mathematical theory of probabilities is applied by Captain Noble to obtain this result, is singularly elegant, and the calculations necessary for carrying it out in actual practice are remarkably simple. Its general correctness is sufficiently proved by its acceptance and adoption by the highest authorities in artillery practice.

3. The objections which have been raised against the system of probable rectangles may be reduced to four in number.

In the first place it has been objected, that the determination of the accuracy by the *area* of the rectangle takes no account of the *form* in which the shot may be distributed. A gun, for example, which has a probable error in range of 40 yards, and in lateral deviation of 5 yards, will be pronounced equally accurate with one that has an error in range of 20 yards and in deviation of 10 yards, or one with an error in range of 200 and in deviation of 1 yard. For here all the areas are equal, although the shooting of the gun is of very different character in the three cases.

Now if there were any clear and logical reason why different values should be assigned to errors in the two directions, and if the differences in these values could be stated in any definite way, a test of accuracy that did not include these variations would undoubtedly be defective. But unfortunately this is not the case. The question has over and over again been submitted to the most eminent and experienced artillerists, and the differences of opinion are so wide as to shew that it is hopeless to arrive at any definite conclusion in this way. Some will consider error in lateral deviation of more importance than in range; others, the contrary; and this is natural when we consider the variety of objects for which, and ways in which, artillery may be used. In firing, for example, at lines of men in front, error in lateral deviation is of less importance than in range; but in firing at columns, or at the same lines in flank, the contrary is the case. In firing from a fort at a ship approaching or leaving, error in range is of less moment than in deviation. In firing at her broadside on, the reverse is true. For these reasons, Captain Noble has preferred to adopt a definition of accuracy founded on a basis of mathematical exactitude, and free from all arbitrary or empirical distinctions; and I shall hereafter shew that it is a legitimate consequence of this principle that the accuracy must be measured by the *area* of the rectangle only, independent of the *form*.

4. Then secondly, it is urged that it would be more natural and more correct to judge of a gun by the position of its shots on a *vertical* than on a

horizontal target, and that the figures obtained in the two cases would not be similar. But a little consideration will shew that the area in one case will be only a simple multiple of that in the other, (for the width is the same in both, and the length on the horizontal is only a simple multiple of that on the vertical); so that for two guns tried under similar circumstances, the ratios of the probable areas, in each case, will be the same; and therefore the relative accuracy of the two guns will come out precisely similar, whether the vertical or the horizontal target be used.

5. A third objection is, that the probable rectangle does not give the same result as would be deduced from what is called the "figure of merit" system, usually adopted in testing small arms. This is true, as the two systems are founded on different principles, and I shall hereafter endeavour to shew that Captain Noble's is the more correct and the preferable of the two.

6. The fourth and last objection has more foundation than either of the others; it is, want of completeness. The system of probable rectangles was only intended by its author to apply to guns fired at about the same range, and with about the same angle of elevation; and hence it is not applicable (without further provisions than those hitherto given), to the comparison, with each other, of guns fired at *different* ranges, and *different* angles.

For suppose two guns to be fired at very different ranges; it is evident that the spread of the fire, increasing largely with the range, will cause the more distant shot to fall more widely than the other, and consequently to form a much larger probable rectangle, though the gun may, when properly compared, prove to be equal or even superior in accuracy.

Again, if two guns are fired at the same range, but with different elevations (as might be the case under different charges of powder), the one with the flatter trajectory would, although the accuracy might be equal, make a longer rectangle, and therefore one of larger area, than the other. An example will illustrate how this difficulty may arise. Suppose it were desired to test the comparative accuracy of three guns, by firing them at several different elevations (giving of course widely different ranges), and with projectiles of several different kinds; and suppose it were found that while one of the guns would turn out the most accurate at one range, or with one projectile, another would be superior at another range, or with another projectile. Now, although the probable rectangles would give a fair test of the accuracy of the three guns at the same elevation, and the same (or about the same) range, the comparison could not, without new provisions, be carried further, and consequently no summary of the aggregate results of the whole series of trials could be made.

I conceive it would not be difficult so to extend and amplify Captain Noble's method as to fit it for this case, but I propose now to offer some observations on the subject generally.

7. Premising that the accuracy of a gun must always be tested by a large number of shots fired, with the axis in a fixed direction, the first question is, as to the *position of the target* on which these shots shall be received and recorded.

There are three ways in which the target may be placed, and which will be at once explained by the following figure.

Fig. 1.

In the first place, the target may be a *horizontal* one, i.e. the shot may be allowed to fall on some level surface, as is the usual way when practice is carried out on the sands.

Or secondly, the target may be placed *vertically*, which is the usual way, I believe, in small arm practice.

Or thirdly, it may be placed at right angles to the line of trajectory, so that the paths of the various shots (which may for this purpose be assumed parallel at that point) will be *normals* to the plane of the target. It is clear that this (although I am not aware that it has been before proposed) is the most correct position, as being the only one in which the errors of the shot in the direction of range are represented on the target without distortion. I call it the *normal target*, and propose throughout this paper, unless otherwise stated, always to consider the target as placed in this position.

It is right however to state that, for low elevations, the *vertical* target may practically be considered as coinciding with the normal one, the distortion being very small; and also that in many cases it is perfectly indifferent which of the three targets is used, inasmuch as having the positions of the shots on one, we can, if we know the *angle of descent* of the shot, easily adapt them to the others. Assuming as before the paths of the various shot, for this small distance, to be parallel, and the angle they make with the horizontal to be represented by θ, then we shall have for errors in the direction of range,

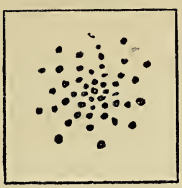
$$\text{Error on vertical target} = \text{error on horizontal target} \times \tan\theta \quad \ldots\ldots(1)$$

$$\text{Error on normal target} = \text{error on horizontal target} \times \sin\theta \quad \ldots\ldots(2)$$

The errors in the other direction may, without sensible error, be assumed the same on all.

8. Suppose then, a normal target to be set up, sufficiently large to catch all the shots, and a gun to be fired at it a great number of times, with its axis always in precisely a similar direction. Assuming for the present, as the simplest case, that there is no tendency to err more in one direction than another, we shall find the marks distributed on the target somewhat in the following manner; that is clustered round a central point in numbers gradually diminishing as their distance from this point becomes greater.

Fig. 2.



9. The first thing to determine is the position of the central point. This is not directly shewn by the shooting; indeed, it is quite possible that it may not exactly coincide with any one of the shots. It must consequently be found by calculation, and the laws of probabilities teach us that it should be in that position where the *sum of the squares of the distances from it to the various shots, will be a minimum;* and this is known to be the property of the centre of gravity of all the shots, which is easily found by well known rules. The point thus found is then, most probably* the true centre where the gun, if it had *no error,* would deliver all its shot, and is therefore the point at which it may be said to be aimed. It is a very important element in all calculations of accuracy, and I shall call it the *centre of impact,* or *point of aim.*

10. Having determined this point, let us now endeavour to form some idea of the accuracy of the gun.

Perhaps the most obvious mode of doing this, would be to adopt a plan often used in comparing the accuracy of small arms, i.e. to measure the linear distance of each shot from the central point (or what is called its *absolute error*); to add the whole together, and to divide by their number. The quotient will give a quantity which is popularly called the "*figure of merit,*" or which may be more definitely termed the *mean absolute error.* This quantity will undoubtedly give some idea of the accuracy of the gun, for when we find the "figure of merit" to be less, we may rightly infer the accuracy to be greater, and *vice versâ.*

11. But suppose we are engaged on a problem which requires us to go farther, and to define *how much* better one gun is than another. We have no ground whatever for assuming the degree of accuracy to be proportional (inversely) to the mean absolute error. It may vary, for aught we know, as the square, or the cube, or the square root, or in no definite proportion at all. We can only say that a gun that makes a small figure of merit is a better gun than one which makes a large one; *how much* better, we have no right to pronounce without further reasoning.

12. To guide us in this reasoning, we must enquire, what do we mean by the accuracy of a gun? How do we define the term? To be enabled to

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* This probability being greater, in proportion as the central point is deduced from a larger number of rounds.

answer this question, we must propose another. What is the object of accuracy? What use or duty of a gun is accuracy intended to promote?

To this there can be but one answer. Clearly the duty of a gun is to *hit the object aimed at;* and that gun will be most accurate that best performs this duty. And hence the *degree* of accuracy of a gun is evidently measured by the degree in which it promotes the efficiency of the gun in this respect. For example, if two guns are each fired 100 rounds, at a small object, under precisely similar circumstances, and one gun hits it 10 times, and the other 20 times, it is matter of common sense that the second gun will be twice as useful;—twice as well adapted to its duty;—in short, *twice as accurate* as the first one.

Now the number of times a gun will hit its object, *cæteris paribus,* in a large number of rounds, is equivalent to what mathematicians call the *probability* of hitting it, and hence we arrive at the conclusion that by the accuracy of a gun is meant simply the *probability* of its hitting the object at which it is aimed.

13. It is however necessary to the correctness of the definition that the object should be of *small size;* for of course if it were very large, a bad gun would be almost as likely to hit it as a good one. Any dimensions not exceeding the mean error of the best guns will answer the purpose in a practical point of view; but the principle becomes more correct when the object is reduced to an *indefinitely small area,* covering what we have called the centre of impact, or point of aim.

And hence the *probability of hitting this small area,* is the true scientific definition of the accuracy of the gun.

14. If now we turn back to our attempt to determine the accuracy of a gun by its "figure of merit," or mean absolute error, we shall at once see that this quantity of itself tells us nothing to the purpose; for it only gives the degree of average *proximity* to the centre, which by no means corresponds with the probability of hitting it. It is indeed possible, in some cases, to *deduce* the probability from the mean absolute error;* but as we shall hereafter shew that there is a better method of finding this probability, of much more general application, we need not consider this "figure of merit" system further. It is merely a rough popular mode of estimation, devoid of any scientific basis, and its use is unjustifiable where any scientific accuracy is required.

It is however worth while to add that this system fails, like that of the probable rectangles, to give any means of comparing the accuracy of guns tried at different ranges. For it is evident that a gun fired at a long range will give a much greater figure of merit, and therefore appear much more

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* If the error of the gun is equal in all directions, and l = mean absolute error, deduced quadratically, then the probability of hitting an indefinitely small circle of radius $= dx$, covering the centre of impact, will be $= \frac{1}{l^2} dx^2$, that is, the accuracy varies inversely as the *square* of the figure of merit. When the error is much greater in one direction than another, as is generally the case with ordnance, the method fails.

inaccurate than one fired at a shorter range, even though the real accuracy of the first gun might be the greater of the two.

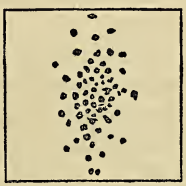
15. But there is a consideration not yet alluded to which has an important bearing on the point now under discussion.

In describing the case above investigated, we assumed at the outset, for the sake of simplicity, that the gun had no tendency to err more in one direction than another, and therefore deposited its shots in a circular form round the central point of impact, as shewn in Fig. 2.

Now this is very seldom the case, for both theory and experience shew that there is almost always a greater tendency to err in one direction than in another. It is true that many causes of error tend equally in all directions; but there are two important ones, almost always present in artillery practice, which act in one direction only. The first is, the variation in the initial velocity of the shot, caused chiefly by irregularities in the strength or burning of the powder, and which tends to produce *vertical* error on the normal target, or what is called "error in range" on the ground. The second is the disturbance of the position of the gun by the commencement of its recoil, which also acts in the same direction as the former one, the first movement of the axis being almost exclusively in elevation.

These two causes combining together will tend to magnify the vertical errors on the normal target, and so to produce an elongated cluster somewhat like this figure.

Fig. 3.



The proportions of the elongation will be very variable. Indeed, I have met with some cases in which the figure, contrary to the usual rule, has been elongated in the horizontal instead of the vertical direction; but these are exceptional, the probability being that if enough rounds were taken, we should always find the vertical exceed the horizontal dimension.*

16. This fact, that the errors of the shot follow a different law in the vertical and horizontal directions, naturally points to another method of estimating their positions, far more simple and appropriate than by taking their absolute distances from the centre. This is the plan generally followed

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* This peculiarity of figure in the practice of guns deserves more investigation. It might be easily inferred from the probable rectangles, if the angle of descent were ascertained; or the adoption of the "test target" system which I propose hereafter, would shew it as a part of the process itself, without trouble. I am informed by Captain Noble that in some very carefully made experiments with a 12-pr. Armstrong gun, the variation in the "angle of departure" was about five minutes,

in mathematical calculations, whenever the positions of several points on a plane surface have to be considered, and called the method of *rectangular co-ordinates*, the application of which to the case in question is exceedingly simple and easy.

17. Having found the probable mean centre of impact as before (by taking the centre of gravity of the whole of the shots registered) draw through it a vertical and a horizontal line, as in the following figure.

Fig. 4.

Then, taking any shot a as an example, its position will be accurately defined by two co-ordinates, x and y, drawn parallel respectively to the horizontal and vertical lines before mentioned. We will call the distance y, the *vertical error* of that shot, and the distance x, its horizontal error.

18. Suppose next we wish to find the *mean* errors in both directions. The most simple and natural mode is to add all the vertical errors together, (both above and below, without regard to sign) and to divide by the total number. This will give the mean vertical error; the mean horizontal error may be obtained in the same way. These mean errors are said to be determined *lineally*. They correspond with the "*écart moyen*" of the French artillerists, and we may denote them, in the French notation, by the symbols K and H respectively. So that

$$H = \text{mean horizontal error (determined lineally)} = \frac{\Sigma_1 x}{n} \quad \ldots\ldots\ldots\ldots (3)$$

$$K = \text{mean vertical error (determined lineally)} = \frac{\Sigma_1 y}{n} \quad \ldots\ldots\ldots\ldots (4)$$

19. But the term *mean error* is somewhat vague. A mean quantity is not necessarily a simple arithmetical mean; for the way it is advisable to find it often depends on the purpose for which it is to be used. In this case, the whole problem being one of probabilities, mathematical considerations teach us that we shall have a greater chance of being correct, if we estimate the mean error in another way, viz. by adding together the *squares* of the separate errors, dividing by the number, and taking the square root of the quotient. The mean errors thus obtained are said to be determined

quadratically. They correspond with what the French call the "*moyen écart*," and may be represented by h and k, respectively,* thus

$$h = \text{mean horizontal error (determined quadratically)} = \sqrt{\frac{\Sigma.x^2}{n}} \quad \ldots\ldots\ldots (5)$$

$$k = \text{mean vertical error (determined quadratically)} = \sqrt{\frac{\Sigma.y^2}{n}} \quad \ldots\ldots\ldots (6)$$

20. Now having these mean errors, taken from a sufficient number of shots upon a normal target, we have all that is necessary for determining the accuracy of the gun; and moreover they possess the great advantage over the single absolute distance plan, that they shew, of themselves, the tendency of the gun to error in the two directions respectively. It remains to point out how the probability of hitting the centre of impact (which we have stated to be the correct definition of the accuracy of the gun) may be deduced from them.

21. In order to simplify the expressions used in the following somewhat complicated formulæ, we will make

$$p = \frac{1}{h\sqrt{2}} \quad \ldots\ldots\ldots (8)$$

$$q = \frac{1}{k\sqrt{2}} \quad \ldots\ldots\ldots (9)$$

p and q being called the "measures of precision" in each direction.

Assuming that there are no abnormal causes of error tending to produce special variations, the laws of probabilities give us the following theorem applicable to this case.

Taking first the horizontal errors; let us call an error to the right +, and an error to the left −.

Then the probability of a shot striking at a horizontal distance $= +x$ (see Fig. 4), to the right of the centre line (or to speak more correctly between the distances x and $x + dx$), will be

$$= \frac{p}{\sqrt{\pi}} e^{-p^2x^2} dx \quad \ldots\ldots\ldots (10)$$

And, similarly, for the vertical errors; let the errors above the centre be called +, and those below −.

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* If the number of shots is not very large, it has been shewn by Captain Noble that it will be more correct to divide each of the mean errors by $n - 1$.

If a very large number of rounds are taken, it is found that

$$\frac{h}{H} \text{ or } \frac{k}{K} = \sqrt{\frac{\pi}{2}} = 1{\cdot}25 \quad \ldots\ldots\ldots (7)$$

Then the probability of striking at a distance $= +y$ above the centre, will be

$$= \frac{q}{\sqrt{\pi}} e^{-q^2y^2} dy \quad \ldots\ldots (11)$$

The probability therefore of hitting a very small area of the target, situated as at a on the figure, will be the multiple of the two probabilities on which it depends, i.e.

$$= \frac{pq}{\pi} e^{-(p^2x^2 + q^2y^2)} dx\, dy \quad \ldots\ldots (12)$$

22. Now suppose this very small area to be situated as at b, i.e. close to the central point, making x and y each $= 0$. The probability of hitting it, which may be taken in practical language to be the same as that of hitting the centre of the target, will be

$$= \frac{pq}{\pi} dx\, dy, \quad \ldots\ldots (13)$$

and substituting for p and q their values in Equations (8) and (9), the probability becomes

$$= \frac{1}{2\pi hk} dx\, dy^* \quad \ldots\ldots (14)$$

From which we see that the *accuracy of a gun is inversely proportional to the product of the mean vertical and horizontal errors*, i.e.

$$\text{Accuracy of gun} \propto \frac{1}{hk} \quad \ldots\ldots (16)$$

23. We can now shew that this determination exactly corresponds with the measure of accuracy adopted by Captain Noble, namely, the *area of the probable rectangle formed on the horizontal target.* For if we project the marks of the shots from the normal to the horizontal position, by means of Equation (2), and then deduce from them the area of the probable rectangle, we shall find this area always proportional to hk, so long as the descending angle of the shot remains the same. And, moreover, if the product hk, and consequently the area of the probable rectangle, be constant, the accuracy of the gun will be equal, whatever proportions the sides may bear to each other. And we thus see that the definition of accuracy we have proceeded on, coincides with Captain Noble's.

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* Or making $dy = dx$; we may say that the probability of hitting a very minute square covering the centre of impact, whose side $= dx$, will be $= \frac{1}{2\pi hk} dx^2$. For a circle whose diameter $= dx$, the probability will be

$$= \frac{1}{8hk} dx^2 \quad \ldots\ldots (15)$$

24. The plan of determining the mean errors from the normal target is free from the difficulty experienced with the horizontal target in regard to variable descending angles, as the normal position eliminates all error from this source. But it is still, like the probable rectangles, inapplicable to the comparison of guns fired at different ranges; indeed, I am not aware that any system ever yet brought forward has escaped this difficulty.

25. I venture however now to propose a method which will, I think, meet the case, and will at the same time offer some other advantages. It is exceedingly simple; and is founded on precisely the same principles as those adopted by Captain Noble, being in fact a mere extension of them to a form of the problem somewhat more practical, and of more general application.

26. I propose to measure the accuracy of a gun by the *probability of its hitting*, not an indefinitely small area as hitherto assumed, but *an actual target*, to be called the *test target*, whose dimensions shall be *proportioned according to the range* at which it is to be used, in a mode hereafter explained.

For example: let it be required to compare the accuracy of two guns, one firing at 2000 yds. range, the other at 3000 yds. Let the former be directed at a target one yard square, and the latter at one larger in the proper proportions. Let 1000 rounds be fired from each gun, aim being always taken precisely on the centre. Then if one gun hits its target 100 times (which a good rifled gun will do) while the other hits only 90 times, I propose to denote their relative degrees of accuracy by the direct ratios of these numbers, or as 10 to 9.

27. This mode approaches quite near enough to theoretical accuracy, while it has the advantage of being a kind of test of the most simple, practical and intelligible nature, and one indeed which artillerists and riflemen are perfectly familiar with in every day practice. And it has further the merit of being applicable to practice at any range.

28. I proceed to shew, that in order to apply this method, it is not at all necessary that the guns should actually be fired at the targets as above supposed. It is quite sufficient that the practice be carried on in the usual way, by firing the guns at certain elevations, and registering the places of the shot as they fall upon the ground, precisely as for the system of probable rectangles. All the rest is matter of calculation, as from these data, the number of shot which *would* hit the targets, if the guns were really fired at them, can be deduced with even greater correctness than by actual trial. The only addition necessary to the usual elements given, is the determination of the *angle* of *descent* of the shot, which is by no means a difficult matter.

29. The most convenient form for the test target is a square; it must be supposed to be placed normally, and with its centre precisely corresponding to the centre of impact.

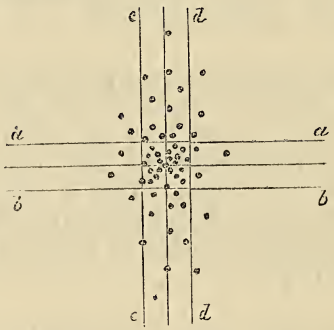
Let the length of its side, as hereafter determined,

$$= a.$$

The mean errors in deflection and range, having been determined (quadratically, so as to give the quantity Captain Noble defines as ϵ_2) from the shots on the ground, must then be applied to the normal target, the former unchanged, giving our quantity h; the latter multiplied by the sine of the descending angle to give k. The problem is then reduced to finding the probability of hitting a square target whose centre coincides with the centre of impact, and whose side $= a$.

To find this we must revert to the reasoning in Art. 21.

30. Let the following figure represent the group of shot referred to the normal position, and let the small square in the centre formed by the intersection of the four lines of a, b, c, d, represent the size of the *test target* we are now considering.



Taking first the errors in a horizontal direction, we have seen (Equation 10) that the probability of any shot falling between the distances x and $x+dx$ to the right of the centre, will be

$$= \frac{p}{\sqrt{\pi}} e^{-p^2x^2}\, dx,$$

whence the probability of any shot falling between the centre and any distance $= \frac{a}{2}$ will be

$$= \frac{p}{\sqrt{\pi}} \int_0^{\frac{a}{2}} e^{-p^2x^2}\, dx \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

And, by the symmetry of position, to the right and left of the centre, the probability of any shot falling within the vertical band formed by the lines c and d (being a distance apart $= a$) will be

$$= \frac{2p}{\sqrt{\pi}} \int_0^{\frac{a}{2}} e^{-p^2x^2}\, dx \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

Similarly, taking the errors in a vertical direction, we shall find the probability of a shot falling in the horizontal band comprised between the lines a and b

$$= \frac{2q}{\sqrt{\pi}} \int_0^{\frac{a}{2}} e^{-q^2y^2}\, dy \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

And, since the probability of two events concurring is equal to the product of the probabilities of each separately, we find that

The probability of hitting the test target, and consequently the ACCURACY OF THE GUN, is

$$= \frac{4pq}{\pi} \int^{\frac{a}{2}} e^{-p^2x^2}\, dx \int^{\frac{a}{2}} e^{-q^2y^2}\, dy \ldots\ldots\ldots\ldots\ldots\ldots (20)$$

the value of which for any given case may be easily found by tables constructed for the purpose.

31. It only remains to explain how the *size of the test target* should be determined for different ranges. This would require some little care at the outset, but being once correctly fixed, all difficulty ends. The conditions necessary are twofold: first, that it shall be sufficiently small; and secondly, that its dimensions shall vary, for different ranges, according to what we may call the *march of precision* of the best guns; so that a gun of the most perfect kind we know may have an equal probability of hitting it at all ranges.

Our ballistic knowledge is not sufficient at present to enable us to determine this condition *à priori*, but it might easily be deduced from good records of the practice of the best guns, and a table might thus be constructed giving the size of test target suited to different ranges of fire. This might further, if necessary, be easily corrected from time to time as further knowledge was gained.*

32. This method of determining the accuracy of a gun gives a certain degree of preference to *compactness* of fire. If two guns firing at the same range, delivered their shot on the target in the manner represented by Figures 2 and 3 respectively, both covering an equal area, but differing in the dispersive form; most artillerists would give the preference to Figure 2, in which the fire was most *compact*. The test target system will shew this advantage, as the probability of hitting a square target of definite size will be greater in the first case than in the second.†

33. I will now state the practical rule by which the "test target" method of determining the accuracy may be applied; having given, the fall

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* According to the information I at present have, I believe that the side in yards, of a test target, which will take one-tenth of the shot of the best guns, will be about $= \frac{r^{\frac{3}{2}}}{110{,}000}$, where r = range in yards.

† The difference will increase with the size of target used at any given range. The disadvantage of want of compactness of fire is also shewn by the "figure of merit" system, but in a much exaggerated degree.

of shot on the ground, and their average descending angle. It will be seen that it is very simple and easy.

(1) Find the mean range, and take out from the target table, the length of the side of test target corresponding thereto, which call a.

(2) Find the mean error* in range (as directed in Captain Noble's paper) and multiply it by the sine of the descending angle. Call this k, and find the value of $\frac{a}{k}$.

(3) Find similarly the mean error* in lateral deviation, call this h, and find $\frac{a}{h}$.

(4) Having these two values, the accuracy of the gun may be found by simple inspection of an accuracy table to be constructed for the purpose.

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* To be determined quadratically. If determined lineally they must each be multiplied by 1·25.

RECENT EXPERIMENTS

WITH

HEAVY RIFLED GUNS IN RUSSIA.

[COMMUNICATED BY A MEMBER OF THE R.A. INSTITUTION.]

THE two following papers do not belong to the series of papers on Foreign Rifled Artillery,* but their intrinsic interest has led to their translation for these "Proceedings" independently. The first is extracted from the Russian Military Journal of 1863, and calls for no particular comment. It describes the progress made at that date in the introduction of rifled guns for field and other services. The second is a much more important document: it professes to be the text of a report presented in April last to the Emperor of Russia, by a commission which included among its members General Todleben and many other officers of distinction, and it embraces the whole question of supplying rifled ordnance of the heaviest calibre to the fleets and fortresses of the Russian empire. It details experiments with nine large steel guns, none under 7 tons in weight, and is worthy of more particular attention from the parallelism of much of the enquiry with those which have been conducted by the Ordnance Select Committee in this country. The paragraphs are not numbered, nor the guns distinguished by any references in the French version, from which the present is a translation, but they will be here designated as follows :—

A, a so-called 9-inch gun of 7½ tons (apparently 245 mm. or 9·65-inch) shunt rifled.
B, a gun of 121 mm. or 8·58-inch rifled.
C, a second 8·58-inch gun, shunt rifled.
D, a third 8·58-inch gun. French rifled.
E, a fourth 8·58-inch gun smooth-bored.
F, a gun of 281 mm. or 11·00 inches. Smooth-bored.
G, a fifth 8·58-inch gun of Blakely manufacture. Parrott rifling.
H, a sixth 8·58-inch gun. Shunt rifled.
I, a seventh 8·58-inch gun rifled on the Prussian system and breech loading.

Guns *A* and *B* burst respectively at the 66th and 109th round, with charges that were certainly excessive. Gun *A*, 45 lbs. of powder and a shot of 269 lbs. Gun *B*, 33 lbs. of powder and a shot of 220 lbs. The English guns of 7½ tons used in the competitive trial of 7-inch muzzle-loading rifled guns in 1864–5,† were not taxed beyond charges of 25 lbs. of

* Vide Vol. IV. p. 343. † Ibid, p. 389.

powder with shot of 110 lbs., one of them reached 630 rounds without any symptom of failure further than that action, partly mechanical, partly chemical, of the inflamed gases on the grooves and interior, which occupies so much space in the Russian report; two others have fired 422 and 431 rounds respectively. They have been since bored up to 8-inch guns. The reasons assigned for the bursting of the guns seem prompted by a needless desire to save the reputation of Krupp's steel. They evidently burst from over work, and the misgivings of those unnamed persons who conceived thereupon doubts as to the resistance of large steel guns, cannot be regarded as altogether unreasonable.

There are several points to which the reader may be specially referred as bearing on questions but recently examined in this country:

(1) That the life of a steel gun used with charges not exceeding $\frac{1}{6}^{\text{th}}$ ($\frac{45}{269}$) is only rated at 250 rounds, §§ 12 and 15.

(2) The unqualified preference expressed for rifled guns over smooth-bored guns of larger calibre but of the same weight, § 15, 2.

(3) Evidence of the indifferent shooting of a Blakely gun rifled on the American plan with a copper expanding base, § 17.

(4) Evidence of the general superiority of breech-loading guns rifled on the forcing system adopted in the British and Prussian artillery, in point of accuracy, §§ 18, 20.

(5) Proof of the satisfactory performance of breech loading guns with a charge as high as 27·5 lbs. § 20, 24, although it is very evident that neither the quality of Krupp's steel nor the mechanical means employed to prevent escape of gas are as yet a complete security against that guttering of the end of the bore and the sides of the breech piece, which leads to the necessity of occasionally refacing the corresponding surfaces in the Armstrong system.

(6) Indications of defective centering in the Prussian system of breech loading from which the British system is free, § 22.

It only remains for the translator to apologize for a certain obscurity and hesitation of style which may be criticised in these pages. He has endeavoured to reproduce the French version before him as faithfully as possible, and it is curiously characterized by those defects; whether they belong to the original, and whether that is in Russ or German, is to him unknown.

Woolwich,
27th November, 1865.

I.

Proceedings of Foreign Artillery: translated from Russ Military Journal. No. 5 of 1863.

"The artillery department is now engaged chiefly on the subject of the introduction of rifled ordnance of large calibre.

"The field artillery is already equipped with twenty-seven rifled batteries of two hundred and sixteen brass rifled 4-pr. guns, and an extra number of 12-pr. rifled guns besides is in course of preparation; and as steel is at last acknowledged to be the best metal for ordnance, 4-pr steel guns have been ordered at the Prince Michael Factory, on the understanding however, that their manufacture should not interrupt that of ordnance of a larger calibre. These 4-pr. guns are to constitute a reserve of the field artillery until they are substituted for the 4-pr. brass guns, when these latter become unserviceable.

"Thus the question of supplying our field artillery with rifled ordnance may be said to be settled; but we have yet to equip our siege parks, our ships and forts, with guns of a large calibre. On this point it has been only decided that these guns should be made mostly of steel, and to load at the muzzle. Until now the labours of our ordnance department have been directed towards the perfection of ordnance on the muzzle-loading system, which must be principally adopted for our naval and siege artillery, as well as in our ports; but to meet fully the requirements of the sea service, it is intended also to arm our ships with breech-loaders, which are more easily worked in a narrow space; therefore, trials are now being made with Wahrendorf's breech-loading 30-pr. guns ordered in Sweden, and with 6-pr. rifled steel guns with a contrivance for loading in the breech on Krainer's wedge principle.

"As regards muzzle-loaders of a large calibre, it has in the meanwhile been resolved for the purpose of more speedily arming our forts with rifled guns, to convert the brass and cast-iron 12 and 24-prs. (about 600) into rifled ordnance. Special sums have been assigned for this work, and the rifling is to be done at *St Petersburg, Keif, Briansk, Novo Georgievsk*, and *Kerson*. Yet these guns are to be only in temporary use until the one hundred and sixty 12-prs. and one hundred and fifty 24-pr. long range guns ordered at Prince Michael works are turned out. The last order for the 24-prs. has, however, been latterly rescinded, seeing that the means are wanting at these works to melt a sufficient quantity of metal for a 24-pr. long range gun; and even after the erection of thirty-two more furnaces, the want of a forging hammer will be found to be a great drawback. Owing to this, only one 24-pr. long range gun for trial has been ordered at the Prince Michael works, it is to be made with a cast-iron coating like that of the 60-pr. steel guns already supplied by Krupp. Should this class of ordnance prove successful, it is intended to order their manufacture at the Prince Michael works, when every means will be afforded for casting and forging guns of a large calibre. The Committee are of opinion that these works should be improved and extended, as it is certainly very desirable to have a steel factory of our own within the empire. There is no doubt but that with all the essential means, and after a fair trial, in six years time the Prince

Michael works will produce the same results which have been reached by Krupp.

"In the meanwhile to possess ourselves of capital steel ordnance of large calibre for service against iron-clad vessels, there is projected a 9-in. steel gun, weighing 230 lbs. to fire a charge of 35 lbs. (Russ), with an elongated cast-iron projectile. Such a gun has been ordered of Krupp, on the condition that if, with the alterations proposed by him, the guns prove serviceable, he is to have an order for fourteen more of 9· and 10·75 in. calibre, these latter to fire with a charge of 50 lbs. (45 lbs. Eng.)

"Exclusive of these guns the special attention of the ordnance department is given to cast-iron guns of large calibre cast on the American principle, on a hollow core as well as to guns fastened with hoops or twisted round with wire. Hooped guns of the largest calibre, i.e. 120-prs. have been ordered at the Olonetz works on the Ural. Trials on an extensive scale are still being carried on with these: with the view of promoting the trials still further, iron hoops for eight guns of the following calibres have been ordered at Paris, 12, 24, 60, and 120-prs., for throwing shells; while at the same time, orders have been issued to Belgium, and to the Kama Volkinsk works, for rings to bind 24-pr. cast-iron ordnance. . . . . .

"Captain Blakely has received an order from the Russian Government for ordnance of a large calibre, the choice of the metal and the method of manufacturing the guns themselves being left to his own judgment. In the meanwhile, anticipating the introduction of strengthened guns into our artillery, it is intended to found a special technical establishment, and to endeavour to secure the services of this gentleman in preparing the manufacture of steel guns, and in strengthening steel and cast-iron ordnance.

"As we have arrived at the conclusion that our guns must be made principally of cast steel, our greatest desire consequently is to increase our steel works. The question of cast steel in its application to coast defences, bears the same significance now as did that, at first, of rifling small arms.

"The Ordnance Committee have called the particular attention of our Government to our situation with regard to cast steel.

"It has firstly been proposed by our ordnance department, to extend the Prince Michael works by erecting twice as many furnaces as there are now (sixteen), and a steam hammer equal to Krupp's.

"Secondly, a well-known foreign manufacturer of Berger steel guns is found willing to establish at his own cost, near St Petersburg, a large factory for making steel ordnance, whilst an order has been given him for four guns of 4 and 12-pr. calibres.

"Thirdly, an officer experienced in metallurgy has been sent abroad to study the Bessemer and other cheap systems of steel manufacture, with a view to their application at our own works.

"Fourthly, the largest manufacturers of the Ural have been requested to follow up the Bessemer system of making steel cannon, a promise being passed that in the event of their success, influence should be exerted to procure them orders; in consequence of this Demidoff's heirs have agreed to commence the casting of iron on the Bessemer principle.

"In addition to all these very important measures relative to rifled cannon, numerous others have been decided upon, or are being experimented. The questions more prominently concerned with these are on solidified

powder, iron gun carriages, breech loading fire-arms: and on very valuable alterations and improvements in our manufacturing establishments.

"The results of trials with solidified powder in America, h ave inducedus for the first time to cause the preparation of five pouds of the same powder at the Okhta works for experiments, (1 pouds = 36·11 lbs).

"The adoption of iron field carriages is already ordered; a carriage for a siege gun is projected; the drawings of new iron carriages for our forts have received Imperial approval, and according to these, two hundred gun carriages for our coasts are already in course of construction.

"We have long ago tested breech loading fire-arms, but now an order is sanctioned for one hundred and twenty experimental rifles for cavalry and infantry. Breech-loading rifles of Green's pattern have been ordered to be supplied to our sharp-shooters in the Caucasus; an order for 3000 samples of these has been issued to America.

"The Tula gun factory with the Imperial sanction is to be handed over to private management, while it is submitted for approval that the artizans and others engaged at the various factories be freed from obligatory labour.

"Three new arsenals are to be established, at Tiflis, Petrofsk, and Ust Laba, in the Caucasus, and new rocket works at Nicolief, those at St Petersburg to be removed."

II.

*Report of the Commission appointed by His Majesty the Emperor of Russia, to enquire into the provision of ordnance for fortresses and for naval service.**

MEMBERS OF THE COMMISSION.

MM. TODLEBEN, Aide-de-Camp General,
CONSTANDULAKY, Lieut.-General,
GREIGH, Major-General de la Suite,
LEIHATSCHEN, Major-Gen. de la Suite
Vice Admiral,
WREWODSKI, Vice Admiral,
TSCHERNAEFSKY, Major-General,
MAJEFSKY, Major-General,
MESTSCHERAEKOW, Major-General,

MM. LOSEFF, Major-General,
GADOLIN, Colonel,
GERN, Colonel,
BOGDANOFSKI, Colonel,
ROSCHKOW, Colonel,
MUSSELINS, Lieut.-Colonel,
WISCHNEGRADSKY, Aulic Counsellor,
SEMENOFF, Captain.

On rifled cannon of heavy calibre.

1. "In the present position of the question of coast defence against a fleet of armoured vessels, it is acknowledged to be absolutely necessary to arm coast batteries with cannon which can act effectively against such assailants; not only at short range, but also at a more considerable distance. To fulfil this purpose the pieces must possess, each in the highest degree, the two qualities which follow:

(1) "To exercise the most destructive action on the armour of any vessel struck.

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* *Pour examiner la fabrication de Pièces d'Artillerie destinées aux Fortresses et à la Marine.* The date of the Report is not given, but is believed to have been April 1865.

(2) "To have the greatest degree of precision possible.

"These two conditions can only be realized by means of rifled cannons of large calibre and made of cast steel, which is the material most suitable for the purpose.

2. "It is very possible in certain cases to make smooth-bored cannon, firing spherical shot, contribute to the effect; but this can be done at short distances only, because as the distance increases so does the destructive action of the projectiles diminish, and with it the accuracy of fire. Smooth-bored cannon can in fact only be placed side by side with rifled cannon, even for effect at short ranges, by augmenting the calibre, but then the facility of working the gun and the rapidity of fire are considerably reduced.

3. "This premised as questionable, it follows that the defences of a fortress exposed to the attack of a fleet of armour-plated vessels, must be armed of necessity with rifled cannon of heavy calibre, and that maritime fortresses which may have disregarded this principle will by so doing have lost their best means of defence, and have blindly set themselves in a very critical position. In conformity with these views of the defence of the sea board, and urged by the immediate necessity which arose last year (1864), to put the fortress of Cronstadt in a condition to oppose the attack of an armour-plated squadron, the government has taken the proper steps to arm the above fortress promptly with rifled guns of large calibre, and has ordered them from M. Krupp.

4. "The question of rifled cannon of heavy calibre being in point of fact one of the most difficult problems in artillery—a problem whose definite solution has not yet been found whether by ourselves or by any other European power—it has been decided as a preliminary measure that we should proceed to the trial of a 9·65-inch* rifled gun selected out of the number of those ordered from Krupp, but without suspending the rest of the order, seeing that the political aspect of the moment called for immediate armament, and did not allow of loss of time.

5. "This gun was tried with a view to arrive at precise data as to the construction of rifled guns of large calibre and of heavy projectiles, and then to determine the amount of destructive action which we may expect them to produce on armour-plated vessels.

"The piece subjected to the trial (*A*) weighed 148·3 cwt., it was muzzle-loading, had parallel grooves† and fired projectiles of 269 lbs. with zinc studs. The charge was 45·2 lbs. of pellet powder (*poudre prismatique*).

"Practice made against iron plates of 4·7 inches to 5·9 inches in thickness has proved that the destructive effect of the projectiles fired from this piece is very considerable: it may therefore be inferred with confidence that such

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* *Neuf pouces*, but referred to below as of 245 m. = 9·65 inches.

† *Rayures parallèles*. Understood to mean shunt rifling.

plates of iron would be indubitably pierced by these projectiles, even at great distances.

"The gun (*A*) burst at the 66th round.

6. "After a very close investigation into all possible causes of this explosion, and after a careful examination of the fragments, as well as of those of the shots fired, the cause of the accident has been decided to be,

(1) "That the projectile was not centred in the bore,

(2) "That the zinc studs were not strong enough, and were sheered by the movement of the projectile in the bore.

"Under these circumstances the body of the projectile must have rubbed the sides and produced bulges which increased with every round, and had the effect of at last wedging it in the bore. It was inevitable that the gun must then burst if the charge were strong enough.*

7. "The second trial took place with a rifled cannon of 8·58 inches (*B*). As for the reason which led to the step from a cannon of 9·65 inches to that of 8·58 inches, it is this: The 9·65 inch gun firing a projectile of 270 lbs. was too light in itself; the weight of the piece was only equivalent to 61 projectiles, and it acted in consequence in a destructive manner on the carriage. To avoid this inconvenience it would have been necessary either to augment the weight of the gun or to give up the use of projectiles of 270 lbs., changing the construction of the latter for some other less advantageous and much lighter form.

"The difficulties which have been experienced in the course of the introduction of heavier cannon, whether of solid structure or strengthened with iron or steel cylinders, and the necessity which was acknowledged of selecting as favourable a form of projectile as possible, while at the same time the piece should weigh about 100 times the weight of the shot, led to the determination to adopt a calibre of 8·58 inches, instead of 9·65 inches, and to bore the 9·65 inch block accordingly.

"Trial was therefore made of an 8·58-inch gun rifled with parallel grooves, constructed on the foregoing principles, and firing projectiles of 220 lbs., with a charge of 33 lbs. pellet powder (*B*).

8. "In the preparation for this experiment all possible care was taken to prevent the wedging of the shot in the bore of the gun. The studs were for greater strength made of copper, and their number increased: besides the driving studs, two rows of centering studs were applied, which bore on the lands, and were intended to prevent the contact of the projectile with the cylinder in issuing from the gun. With the same intention the cylindrical body of the projectile was so proportioned that under no circumstances could it touch the bore, with whatever manufacturing error the parts above described might be affected; the surface of the projectiles was turned, and a

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* The official reader is referred to the Journal of the Commission 2, 3, December, 1863, for further particulars.

particular attention was given to the centering of the shot after the studs had been applied.

"The result of these experiments was that steel projectiles of 8·58 inches fired from this gun have fairly passed through iron plates of 4·7 inch thickness.

"The practice was extremely accurate. The point aimed at was struck with certainty at 233 yards. After obtaining these perfectly satisfactory results, the trial of endurance was proceeded with. The charge was 33 lbs. of pellet powder, and for economy sake cast-iron shot were used. The gun (*B*) burst at the 109th round; the projectile did not reach the butt, and was itself picked up in pieces.

"The fragments of the shot and of the burst gun were examined with care. It resulted from this examination that the gun in all probability burst from the effects of the previous breaking up of the shot, and that the fragments of the projectile produced a stoppage in the bore.*

9. "Although the marks on the fragments of the shot and of the gun were such that it might be concluded that the bursting of the gun was caused by the breaking up of the projectile in the bore, these marks did not altogether explain the result, or account for the previous movement of the projectile in the bore.

"Their character was not so distinct as that of the markings of the first gun; and this circumstance gave room for the advancing of opinions by certain parties in respect to the accident, which have not been confirmed by facts. Some persons conceived doubts as to the resistance of large steel guns in general, quite apart from the fact that they were themselves convinced by the examination of both the burst guns that the metal employed was of exceptional quality—of great tenacity, the steel homogeneous, and the forging perfectly uniform.

"Others attributed the bursting of the gun to the system of grooving, but facts afford no confirmation to this opinion.

10. "To set at rest these questions and these doubts, and to arrive at some final conclusions respecting guns of large calibre, it was determined to try four guns.

(1) "Two guns (*C*, *D*), of 8·58 inches, one, *à rayures parallèles*, the other rifled on the French system, that is to say, with simple grooves contracted at the seat of the shot.†

"The object in view in trying these guns was to determine their endurance under the fire of steel projectiles which cannot break in the bore. The experiment was calculated at the same time to illustrate the influence of the system of rifling on the resistance on the piece.

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* "*Y avaient produit un obturation.*" The official reader is referred for details to the Journal of the Commission, No. 9 for 25 March, 1864.

† The French translation is here as elsewhere somewhat obscure: "*à rayures normales par rapport à la surface de l'âme avec arêtes de sortie ou de clôture des rayures.*"

(2) "A steel smooth-bored gun of 8·58 inches (*E*) which was intended to afford complete proof of the strength of Krupp's steel guns, by its resistance to a great number of rounds fired with spherical bullets and a large charge.

(3) "A smooth-bored gun of 11·06 inches in an 8·58 inch block bored up (*F*) for trial with spherical shot and a large charge. This last experiment was to be the *pierre de touche* both as regards the endurance of the gun, and the action of spherical projectiles of large calibre on iron plates.

11. "The 8·58 inch gun *à rayures parallèles* or shunt rifled, was fired at the iron target at a distance of 1167 yards. It appeared that plates of 4·7 inches were penetrated not only with a charge of 33 lbs. of pellet powder, but also with the charge reduced to 27½ lbs.

"The fire of this gun and of the gun with French rifling with the larger charge (33 lbs.), was in consequence restricted to 46 rounds; and was then continued with the charge of 27½ lbs; 169 rounds with this charge were fired with the former and 240 with the latter. A slight wear of the metal was perceptible in both guns at the seat of the shot, proceeding from the action of the gas in its escape by the windage. This wear is due probably and principally to the mechanical action of the gas. It was more considerable in the second gun than in the first, and was no doubt caused by the greater number of rounds fired. This novel fact, confirmed by experiment, and to which little attention has heretofore been given, is of great importance in relation to the question of steel rifled guns of large calibre.

12. "This fact proves that muzzle-loading guns of large calibre in which the gas is allowed to escape by windage, and which fire heavy projectiles with large charges, even when made of steel of absolutely the best quality (and no one will question that to this category belong the guns of M. Krupp) are subject necessarily to a wearing action, and that the service of the gun cannot be rated higher than 250 rounds without danger of the projectiles producing such injuries in the bore as might endanger it.*

13. "The experiment made by order of the Minister of Marine with the steel gun (*E*) of 8·58 inches, in which spherical balls were fired with a charge of 27·5 lbs. of common powder, have given proof of the great resistance of Krupp's steel guns, and have confirmed the fact already stated. The gun stood 1025 rounds, but the escape of gas by the windage produced a considerable wear on the surface of the bore at the seat of the shot. A similar result followed the trial of the other smooth-bored gun (*F*). This piece, bored up to 11·0 inches from the calibre of 8·58 inches, stood 790 rounds, firing spherical shot of 198 lbs. with a charge of 44 lbs. of pellet powder, after which it was observed that wear of the metal was taking place at the seat of the shot. The wear was however but trifling, so that the piece remained serviceable. With respect to the comparatively small wear of this piece as compared with that of the gun of 8·58 inches (*E*) tried by the

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* The French translation has it "*de crainte que si l'on continuait le tir, les projectiles ne produisissent une obturation dans l'âme du canon.*"

Minister of Marine, it must be attributed to the fact that the maximum pressure of the gas upon the unit of surface of this piece with a charge of 44 lbs. of pellet powder and spherical balls, is sensibly less than in the gun of 8·58 inches with the charge of 27·5 lbs. of common powder.

14. "The practice at the 4·7-inch armour plates has given this result: That spherical steel shot (of 200 lbs.) projected by a charge of 44 lbs. of pellet powder are capable of penetrating such a cuirass at a distance of 934 yards, but the accuracy of fire was much less than that of the rifled 8·58 inch gun. The target was formed by two plates superposed, presenting a mark of 12 ft. 10 ins. in width by 6 ft. high: out of eighteen shots only three struck it.

15. "Recapitulating the result of the experiments we arrive at the following conclusions:—

(1) "That Krupp's cast steel cannon are of very great resistance.

(2) "That rifled guns possess very important advantages over smooth-bored guns of the same weight firing also spherical projectiles of the same weight, as regards their effect on armour plates.

"This superiority of rifled cannon over smooth-bores rests on the fact that their accuracy is much greater, and that elongated shot of a given weight produce more effect on iron plates than spherical shot of the same weight.

(3) "That rifled cannon of steel, of large calibre, muzzle-loading, and in which the escape of gas by windage is allowed, are not well adapted for settling the question proposed, in a manner which shall be quite satisfactory; inasmuch as they are subject to a rapid wear of the metal, for which reason we cannot assign with certainty a longer duration than 250 rounds for a cannon of this description.

16 "Such being the state of the case, it was no longer difficult to determine what course to take to throw more light on the question of the proper guns to oppose to a fleet of armoured vessels.

"It was necessary,

(1) "To give the preference to rifled guns over smooth-bored.

(2) "To set on foot fresh experiments with the former in order to find means of remedying the very serious inconvenience resulting from the liability of the metal in the bore to wear.

17. "To this effect two series of experiments have been taken in hand. The first was concerned with muzzle-loading guns firing projectiles with expanding bottoms of copper (*culots*). These are intended to close the space between the projectile and the bore and thus prevent the escape of gas. The second series had reference to breech-loading guns.

"The projectiles with expanding bottoms of copper were tried in two guns.

"The first on Blakely's system (*C*). The projectiles had no studs, and the movement of rotation was given to them by the expansion of the bottom, whose edges were forced into the shallow grooves of the bore.

"The other gun was grooved *à rayures parallèles* (*H*), and the projectiles were provided with studs.

"The first experiments shewed that the fire of the latter cannon was more regular than that of the former.

"In consequence of this, and looking principally to the application of expanding bottoms to cannon *à rayures parallèles* (of which we already possessed seven pieces), and for which these bottoms might be very advantageous, the fire of the Blakely gun was suspended in order to continue that of the other gun alone. Down to the present time this piece has fired fifty rounds, and the result is that the projectiles with expanding bottoms are less accurate than the ordinary ones with studs.

"Considering the small number of rounds fired from this gun with expanding bottoms, it was not possible to determine exactly to what degree they answered their intended object of preventing the wearing of the metal in the bore of the gun.

"But since experiments had already commenced with breech-loading guns, and good hopes were entertained of favourable results, it was decided that no further enquiry should be made on the subject of projectiles with expanding bottoms, and that all attention should be brought to bear on the enquiries which concerned B.L. cannon.

18. "It may be stated positively that notwithstanding the greater wear of metal which occurs in these guns (*l'evasement plus considerable*) their endurance is not affected, because it can be so arranged in loading the gun, that the axis of the shot shall be centred very nearly in the bore, which will prevent the sticking (*obturation*) of the projectile. To this it may be added that in breech-loading guns the wear is immensely reduced by the hard compression of the lead coating of the projectile,* and after all it must be remarked that all breech-loading rifled guns possess a very much greater accuracy of fire than is possessed by rifled guns of any system loading at the muzzle.

19. "The trial of the breech-loading rifled gun of 8·58 inch calibre (*J*) with Krupp's arrangement for closing the breech was commenced by a determination of its destructive effect on armour plates. The gun was directed against a target composed of an entirely new wooden backing resembling the side of a ship faced with strong new 4·7 inch iron plates. The first round fired was a cast steel shot of 216 lbs., charge 27·5 lbs. of pellet powder" (distance not stated) "the projectile penetrated the wood to a depth of twelve inches, broke the plate easily (*instantanément*) and remained buried in the backing. The base of the shot projected three inches out of the plate. This fresh result was thought sufficient, and the fire at the target was discontinued. The initial velocity of the shot with the charge named above was 1312 ft. (400 m.), and consequently less than that of a projectile of the same

* "*Est infiniment moindre par l'impression assez forte de la chemise.*"

weight fired with the same charge from a B.L. gun, which reached 1345 ft. (410 m.)*

20. "Such being the case, to place the initial velocity of the breech-loading and muzzle-loading guns on a level, a higher charge of 27·5 lbs. was adopted with which an initial velocity of 1420 feet was attained.

"The fire was continued with the charge, employing cast-iron projectiles, to ascertain the accuracy of fire, the facility of manœuvre, and the endurance of the piece. The accuracy of the fire tested by practice at a mark placed at variable distances, was found as would be supposed beforehand, infinitely superior to that of rifled muzzle-loading cannons. Thus for example the shots which struck a target of 9 ft. by 25 ft. at distances varying from 1865 to 2333 feet was more than 70 per cent: while the muzzle-loading gun gave only 30 per cent.

21 "The piece (*J*) stood 400 rounds with a charge of 27 lbs. of pellet powder and remains perfectly serviceable. The mechanism has given great satisfaction, and the manipulation is perfectly simple.

"After the 127th round there was some waste of the metal perceptible at the breech end of the bore close up to the stopper, on the right side, taking the form of scratches, *piqûres*, but on the lower part of the same surface there was a roughness. On that part of the breech stopper which touches the end of the chamber there were corresponding marks. It was inferred that the *gas check* had not completely closed the bore. The wear on the right side must be attributed to the fact that the stopper was not wiped every time, the breech piece consequently could not go quite home, and there remained a space between the *gas check* and the side of the chamber on the right, by which the gas was enabled to escape. Special thin gas rings, *obturateurs*,† were employed to hinder this passage of gas as much as possible. They were placed in the chamber behind the charge in such a manner as to bear with their flat side against a steel circle let into the face of the breech stopper, in the same place as the *gas check* previously employed. A new ring was taken into use at every round. This way of hindering the escape of gas proved more practicable than the former one, nevertheless it could be seen after some rounds that the gas kept escaping, but it was only at one place, marked by a gutter in the side of the ring. This escape was palpably referable to a flaw (*piqûre*) on the surface of the chamber, running longitudinally and growing wider towards the end. The face of the stopper was marked with corre-

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* "The inferiority of the initial velocity of projectiles fired from breech-loading guns, as compared with that of projectiles of muzzle-loading guns may be explained first by the vacant space in the chamber of the former which is greater than in the latter, and second by the greater resistance offered by friction to the movement of the projectile in the bore. However, this loss of velocity finds a natural compensation in the suppression of windage."

So the reporters; but it will be obvious to the reader that if the initial velocity is reduced, such compensation has not taken place.—*Translator's note.*

† The terms *fermeture, bouche de fermeture, obturateur* require the explanation of a diagram. The translator has rendered them in terms which will be intelligible to those who are acquainted with Krupp's system of breech-loading.

sponding gutters. To stop the increase of the flaws in the chamber the ring was turned every 30 or 40 rounds, bringing a fresh place opposite each flaw. After 212 rounds a very slight bulge was observable at the commencement of the grooving; the impressions taken shewed its trifling character, and that it hardly exceeded the one formed in the 11-inch gun (*F*) after the same number of rounds, which gun however stood 600 rounds more, and remained fit for service.

22. "After the 212th round it was inferred from marks on the last lead ring that some of the recovered projectiles had rubbed the lands as well as the grooves. It had been remarked that the impressions of the lands and the lead of the projectiles were not of the same width on opposite sides. There were two marks on some of them, one wider than the other, evidently produced by the same land, but at different instants of the shot's passage through the bore, one at the first movement of the shot, the other later. It was observed on this occasion that the gauge between opposite grooves on the same diameter was less by a line ($\frac{1}{12}$ or ·083 inches) than the diameter of the bore. These circumstances indicated an irregular movement in the bore which could only be attributed to the projectile not having been centred at starting.

"It became necessary to increase the diameter of the last belt of the shot to correct this irregularity; but not to have to enlarge the mould in which the lead coating was cast round the shot, six holes were drilled in the back part of the projectile in which an equal number of studs were cast, having such a relief that the diameter of the hinder part of the projectile behind the studs was only three points (0·02 inches) less than the diameter of the bore. This arrangement being intended to centre the long axis of the shot with the bore in loading as nearly as possible, has sufficed to get rid of the rubbing on the end of the shot. However, the inequality of the impressions made by the lands of the rifling continued as before, which proved that notwithstanding this improvement, the axis of the projectile did not exactly coincide with that of the bore, and that it came into collision sometimes with one side, sometimes with the other, while passing through it.

23. "These irregular movements of the projectile could not be the cause of the indents in the bore, because the soft coating of the shot is not able to produce them; but when once the formation of dints ceases the stoppage of the shot is no longer possible. Irregular movements of a corresponding character ought also to occur necessarily in muzzle-loading guns firing studded projectiles; only the facts are not so apparant, inasmuch as those shot had no soft coating, and consequently, the effect, if produced, escaped observation. It may indeed be affirmed that the irregular movement in the bore must be greater in muzzle-loading than in breech-loading guns, otherwise it would be hard to explain the less accuracy of fire of the former than of the latter.

"Four hundred rounds have been fired with this gun (*J*) down to the present time (April 1865), at the practice ground of Wolkof, and twenty-five rounds with a charge of 22 lbs. common powder at Krupp's foundry, total 425.

"After so many rounds there was a slight increase in the wear of the metal at the end of the grooves. It was already observable all round where the bore unites with the chamber, more at the lower than at the upper part. However, this wear was not more serious than that which appeared after 800 rounds of the experimental 11-inch gun (*F*); and the piece is quite serviceable.

24. "To sum up. The experiments have proved that the 8·58 inch rifled breech-loading guns made by Krupp, of cast steel, possess a very great accuracy of fire; that they produce satisfactory results against armour plates, that they stand 425 rounds and are then fit for service.

"On the basis of the results of actual experiment the Commission nominated by Imperial command to enquire into the manufacture of cannon for fortresses and fleets has acknowledged the 8·58-inch breech-loading gun as perfectly suitable for the armament of coast batteries. It has decided in its immediate introduction, and to convert all the 8·58-inch guns, not only those already made, but also those which M. Krupp has still to deliver, into breech-loading guns.

"At the same time the Committee thought it right not to be satisfied with the experiments actually made with 8·58-inch B.L. guns, but on the contrary to continue their trials until it should be in a position to state more precisely,

(1) "The resistance of these guns to heavier charges;

(2) "The convenience or inconvenience of breech closing arrangement;

(3) "The degree to which the metal is worn;

(4) "The extreme distance at which they are capable of penetrating iron armour plates."

NOTE.—The two following plates drawn from photographs, will assist in making Par. 21 intelligible. The first represents a breech-loading gun of Krupp's in six positions.

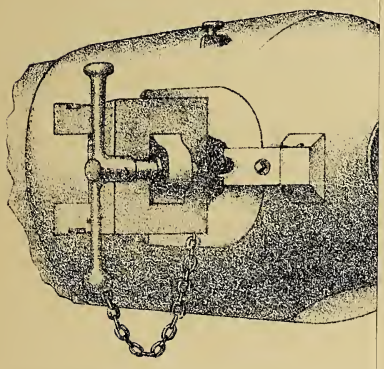
Plate 1, figs. 1, 2. Rear view of the breech-block drawn out to admit of sponging and loading; shewing the block itself, the screw by which it is started, and the sliding clamp by which it is held when in place, to prevent it starting of itself on the discharge. In this position the gas ring is about half out of the slot.

Figs. 3, 4. The breech closed for firing, the sliding clamp pushed home, and holding the screw.

Figs. 5, 6. The breech-block drawn out beyond the loading position so as to completely clear its face, and to permit the steel or copper gas ring which is let into the face, to be cleaned, or exchanged for a new one.

Krupp's Patent

1 *Po*



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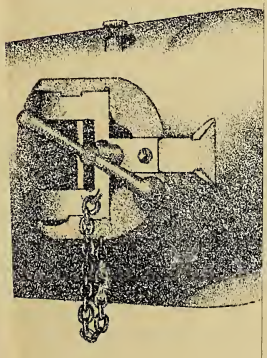

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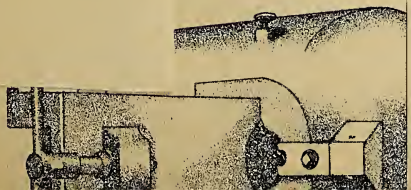
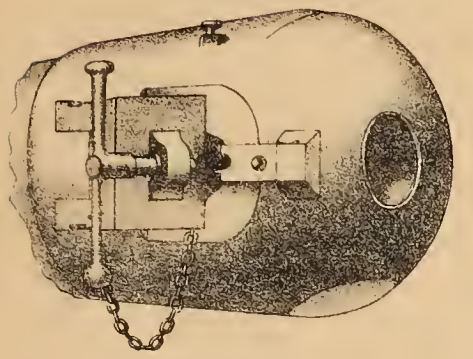


From a Photograph. Coates desin

Lithographed at

Krupp's Patent system for Battering Guns

1 Position for loading



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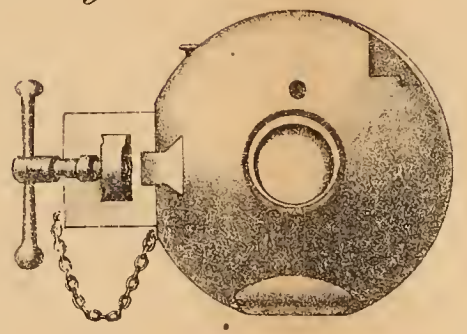
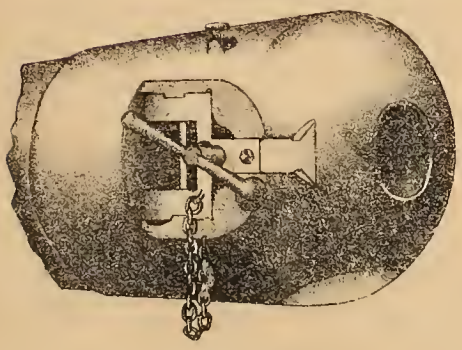


3 Position during firing



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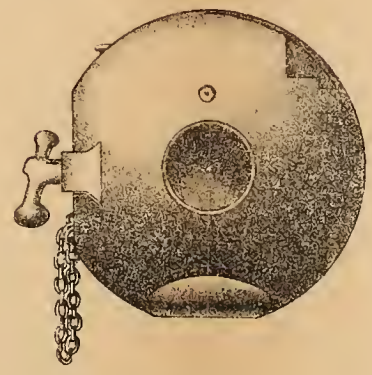
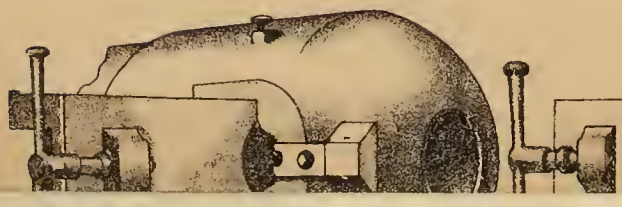


Position for cleaning

5



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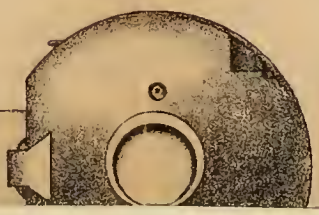
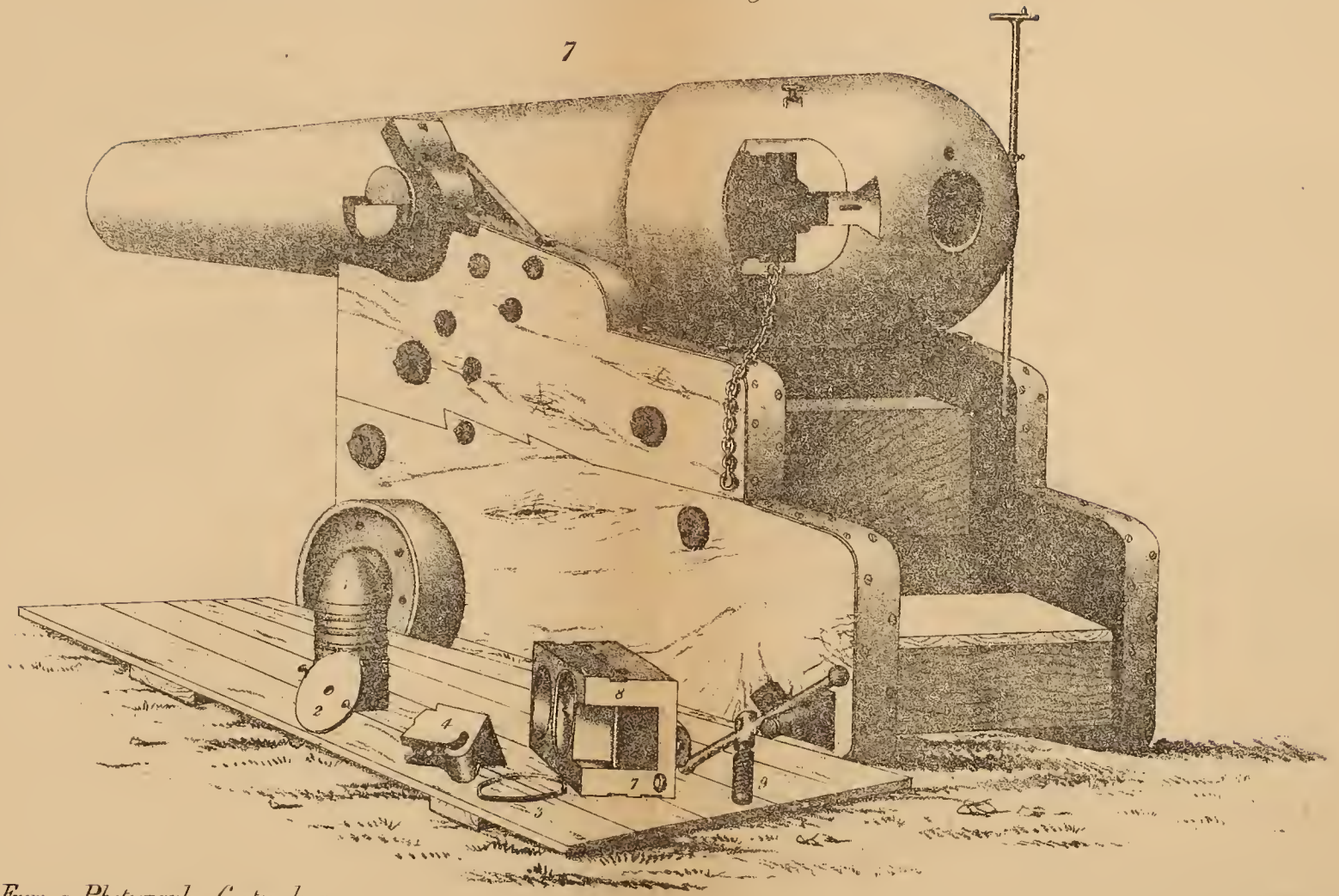


From a Photograph. Coates dessn

Lithographed at the Royal Artillery Institution

Krupp's Patent system for Battering Guns



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Lithographed at the Royal Artillery Institution

Plate 2. The gun with its fitments are here represented apart.

(1) Shot leaded on the Prussian system.

(2) Plate for refacing the block.

(3) Steel or copper ring, of triangular section, about 0·33 in. width towards the powder chamber, by 0·37 in. depth. The form of this ring is such that the gas exercises a wedge-like action within it, pressing the face of it against the circumference of the bore, and thus closing the junction of the block and gun.

(4) The sliding stop for locking the block.

(5) Aperture in the breech-block through which the charge is introduced and the gun sponged.

This aperture in the most recent examples is lined with a sliding gun-metal tube ingeniously contrived to advance towards the bore of the gun as the block recedes from it, so that in the loading position when the face of the block is nearly half an inch clear of the front of the slot, the tube protrudes and touches it. The object is to prevent fouling being drawn into the open space, and the motion is effected by a couple of guide pins, one above and one below, which work in inclined grooves on the upper and under surface of the block.

(6) Circular recess in the face of the block into which the steel or copper ring (3) is fitted when the block is in position for firing, this recess is in prolongation of the bore.

(7, 8) Breech block shewing the grooves above and below by which it is guided, the handle for withdrawing it, the several stops, and the staple in which the locking screw (9) moves.

(9) Screw with lever handles for setting the block home if required, and for starting it. The mode of action is best seen in figs. 1 and 2, Plate 1.

PETTMAN'S PERCUSSION FUZES.

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In preceding papers[1] I have described two of the fuzes for rifled shells; and I propose hereafter to furnish descriptions of the other rifle ordnance fuzes. Having, however, been requested to describe the Pettman percussion fuzes used until lately only with smooth-bore ordnance, but now with certain of our rifled guns, and my notes upon these fuzes being sufficiently complete to enable me to comply with this request without delay, I have drawn up the following paper on the subject; prefacing it with a few remarks on the distinction between "Percussion" and "Concussion" fuzes, —a point upon which much uncertainty has existed.

A Percussion or a Concussion fuze is one which is independent of the element of time of flight, and which depends wholly upon impact for its ultimate action.

The distinction between Percussion and Concussion fuzes was until 1863 altogether arbitrary, and the application of the terms depended upon the sense in which the inventor of any particular fuze chose to apply them. Sometimes the name "Percussion" has been restricted to such fuzes as contain a percussive or detonating arrangement, while those fuzes have been called "Concussion" which are independent of any such arrangement;[2] in other cases the application of the terms seems to have been rather a matter of accident than founded upon any accurate or well considered distinction.[3]

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[1] Vide Vol. IV. pp. 171, 280.

[2] Sir Howard Douglas adopts this distinction. He says, "A concussion fuze is provided with an internal mechanism, so nicely adjusted as to withstand the first shock the shell receives, viz. that occasioned by the explosion of the charge, and resist any other that may be occasioned by grazing short, while it shall yield to the concussion occasioned by the impact of the shell on the body struck; this concussion, by shaking the burning composition of the fuze into the loaded cavity of the shell, instantly causes the latter to explode.

A "percussion" fuze or shell is one fitted or filled with a chemical composition of highly explosive character which bursts the shell at the moment of striking, without being previously ignited."—*Naval Gunnery*, p. 2, note.

[3] A good instance of this is afforded in the naming of two of the Armstrong fuzes, one, the iron fuze which was in use until 1862, was called a "concussion" fuze; while the C pattern fuze by which it was superseded, and which depended upon identically the same principles of action, was called a "percussion" fuze; indeed, the C pattern percussion fuze was itself on its first introduction called a concussion fuze.

Perhaps the best distinction which could be drawn, looking to the natural meaning and application of the words,[1] would be to call those fuzes which depend *upon the direct impact* of the fuze "Percussion," and those which do not require for their action such direct impact, but merely the concussion resulting from the impact of the shell, "Concussion" fuzes.

The adoption of this definition, however, would have the effect of altering the nomenclature of all the fuzes of this class, whether rifle or smooth-bore, at present in the service to Concussion, since there is no existing fuze which depends upon *direct impact* for its action.[2]

In 1863[3] a definition was suggested by the Ordnance Select Committee, and adopted to govern the future application of the words percussion and concussion.

This definition is as follows: "A percussion fuze is one which is prepared to act by the shock of discharge, but put in action by the second shock on striking the object; a concussion fuze is one which is put in action by the shock of discharge, but the effect of that action is restrained until it strikes the object."[4]

Under this definition all existing fuzes become percussion,[5] and the only fuze (now no longer in the service) which fulfils the requirements of a concussion fuze is Freeburn's,[6] on which, indeed, it is probable this definition, by an inductive process, was framed.

There are at present two percussion fuzes for smooth-bore ordnance; invented by Mr Pettman, a foreman in the Royal Laboratory, Woolwich.

(1) Pettman land service percussion fuze.
(2) „ sea „ „ „

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[1] "*Percussion*, the act of striking one body against another."—*Imperial Dictionary.*

"*Percussion*, a striking, a shock."—*Webster's Dictionary.*

"*Percutio*, to strike, to hit, &c., &c."—*Ainsworth's Latin and English Dictionary.*

"*Concussion*, Latin, *Concussio*, from *concutio* to shake, from *con* and *quatio, quasso*, to shake or shatter."—*Imperial Dictionary.*

"*Concussion*, a shaking."—*Webster's Dictionary.*

"*Concutio*, to shake, to jog, &c., &c."—*Ainsworth's Latin and English Dictionary.*

The meaning of the two words broadly expressed and for the practical purpose now under consideration may then be taken as follows:—*Percussion*, a striking; *Concussion*, a shaking.

[2] With the exception perhaps of the Boxer 2-inch time fuze for rifled ordnance, which however is generally spoken of as a time fuze, its employment as a percussion fuze being to a certain extent exceptional. But when used as a percussion fuze, this fuze does depend upon direct impact; it must be actually struck and driven into the shell. The term percussion would therefore be rightly applied to it, under the definition suggested.

The percussion fuzes for rifled ordnance, C Patt., Dyer's, Freeth's, and the Pillar, depend also, it is true, upon the shell striking head foremost, or nearly so, but not upon the actual impact of the fuze.

[3] January 16th, 1863, W. O. C. 822, par. 725.

[4] *Ibid.*

[5] It is a question whether the Boxer 2-inch time fuze for rifled ordnance when used to act on impact should not under this definition be called a concussion fuze, since it is put into action by the shock of discharge in the same sense as Freeburn's fuze, while the effect of that action is restrained until the object is struck.

[6] See preceding note.

(1) PETTMAN LAND SERVICE PERCUSSION FUZE[1] (Figs. 1, 2), consists of seven principal parts, viz. :—

The Body,	Lead Cup,
Top Plug,	Cone Plug,
Bottom Plug,	Detonating Ball,
Steady Plug.	

PETTMAN'S LAND SERVICE PERCUSSION FUZE.

Fig. 1.

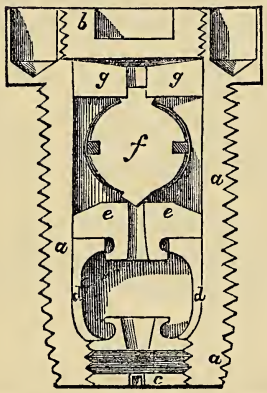
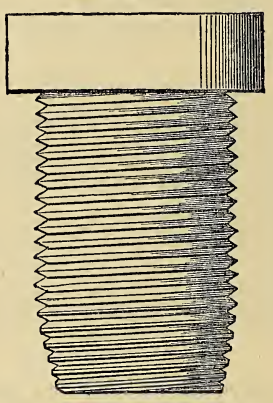


Fig. 2.



The Body (Fig. 1, *aaa*), is made of gun-metal.[2] It is two inches in extreme length; and is conical[3] in form and screwed to fit the fuze holes of common spherical shells.[4] Above the screwed part is a plain projecting shoulder upon which the fuze rests when screwed home; and upon the top of this shoulder are four wrench holes, equidistant from one another, by means of which the fuze is screwed into or removed from the shell.

The body is hollow from end to end, being tapped[5] at top and bottom to receive the top and bottom plugs.

The interior is otherwise plain and cylindrical; with the exception of a slight rounding inwards immediately above the bottom plug.

The Top Plug (Fig. 1, *b*), is a cylinder of the same alloy as the body, screwed to fit the upper end of the fuze;[6] on its upper side is a square key hole by which it is screwed into the body, or removed for the purpose of inspection or repair.[7] This plug closes the top of the fuze.

The Bottom Plug (Fig. 1, *c*) is a cylinder of the same alloy as the body, screwed to fit the lower end of the fuze.[8] On its upper side it has a small

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[1] Adopted 30th October, 1861, W. O. C., 739, par. 414.

[2] Copper 11 lb., tin 1 lb., zinc 1½ oz.

[3] The common fuze hole taper, one inch in 9·375 inches. The extreme lower end of the fuze is slightly though almost imperceptibly rounded.

[4] The thread is right-handed and 14 to the inch.

[5] Right-handed, 20 threads to the inch.

[6] See preceding note.

[7] It is an advantage of these fuzes that they admit of ready inspection and repair of the interior arrangement when required.

[8] See note 5.

projecting stud; and on its under side a small cut by means of which it is screwed into the body.

This plug is perforated with two holes: one vertical, through its longer axis, to serve as a fire hole through which the flash of the exploded detonating composition may communicate with the bursting charge; the other horizontal, and intended for the reception of a strand of quickmatch, to prevent the powder dust from the bursting charge working into and choking the fuze.

The Lead Cup (Fig. 1, *dd*) is a hollow cylinder of pure[1] lead, completely open at the bottom but having merely a small hole at the top. This cup rests upon the bottom plug, the lower part of it adapting itself to the rounded form of the interior of the lower part of the body, and thus surrounding, though not touching the stud of the bottom plug.

The Cone Plug (Fig. 1, *ee*) is made of rather a harder alloy than the body of the fuze[2] for a reason which will presently appear.[3]

It is called the "cone" plug from the top edge being bevelled, which gives the upper part of the plug a conical form; otherwise it is a plain cylinder which exactly fits the interior of the body. From the lower side of the plug projects a stud similar to that upon the bottom plug; and the plug is perforated vertically with a fire hole.

The cone plug rests upon the lead cup, its stud entering the small hole in the top of the cup.

The Detonating Ball (Fig. 1, *f*) is a solid sphere of the same alloy as the cone plug, it is roughened, or "milled," over its surface and a groove is cut round its horizontal circumference, for the double purpose of allowing a greater quantity of detonating composition to be placed upon the ball and of giving that composition a better hold.

At the extremities of the vertical axis of the ball are two projections; the lower one is conical, the upper cylindrical with a small shoulder round its base. Round the neck of each projection is a small groove. The ball is plastered over its whole surface up to, but not in the grooves at the neck of each projection, with the following composition.[4]

Potash, chlorate of	6 oz.	Damped into a paste with spirits, methylated, 1 quart; shellac, 112 grains, in the proportion of 40 minims of the varnish to 100 grains of composition.
Antimony, sulphide of ...	6 „	
Sulphur, sublimed	½ „	
Powder, mealed	1 „	

The composition is covered with fine gut skin[5] tied on with silk cord and varnished, and afterwards with thin silk[6] similarly secured and varnished.

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[1] The purity of the lead is a very important point, the strength of the cup being calculated upon the assumption that the lead employed is perfectly pure, any admixture which may tend to increase the strength of the lead cup would tend to diminish the certainty of action of the fuze with low charges; on the other hand, any decrease in its strength would render the fuze liable to accidental explosion. The cup should weigh between 190 and 200 grains.

[2] The alloy is, copper 7 parts, tin 1 part; or expressed decimally, copper 87·5, tin 12·5.

[3] See p. 79.

[4] This composition is the same as that used for the quill friction tube, with the exception of the varnish.

[5] Sheep's gut skin. [6] Sarsenet.

These coverings of gut skin, silk and varnish, not only diminish the sensibility of the ball to the point requisite to secure it against premature explosions,[1] but they also effectually protect the detonating composition from damp.[2]

The ball rests with its lower or conical projection in the fire hole of the cone plug; the upper or cylindrical projection entering a hole in the steady plug.

The Steady Plug (Fig. 1, *gg*) is a cylindrical plug of the same alloy as the ball and cone plug, exactly fitting the interior of the fuze. A hole is drilled through the vertical axis of the plug, not to serve as a fire hole but for the admission of the upper projection of the ball. The top side of the plug is slightly hollowed out.[3]

The steady plug occupies a position in the fuze immediately underneath the top plug and immediately over the ball.

When the fuze has been placed together with the several plugs and parts occupying the positions described, the key hole in the top plug and the cross cut in the bottom plug are filled with shellac putty, and discs of fine paper[4] are secured over the top and bottom of the fuze[5] with shellac varnish, the better and more completely to exclude moisture. A leather collar is secured by shellac varnish to the under part of the shoulder of the fuze.

The number of thousand of the fuze, the year and month of issue and a Roman numeral I (for Pattern I) are stamped on the top of the fuze[6] between the wrench holes. The whole of the exterior of the fuze is lacquered.

Action.

These fuzes require no preparation. Their action is as follows:—The shock of the discharge crushes up the lead cup,[7] a result which is due partly to its own inertia, and partly to that of the cone plug, ball and steady plug which rest upon it.[8]

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[1] Such as would probably result from the friction of the ball, if the composition were naked, against the inside of the fuze during the flight of the shell, or on the first shock of discharge.

[2] Pettman's fuzes are therefore little, if at all, sensible to the effects of damp, as independently of the protection afforded by the covering of the ball, the fuze itself is securely closed, and the ball, the only part liable to deterioration, is thus doubly protected.

[3] The only object of this hollowing out is to remove the "burr" which is necessarily thrown up by the drilling of the hole and which would prevent the steady and top plugs from coming into close contact.

[4] Tracing paper.

[5] Over the whole of each end, the paper is subsequently broken at the four wrench holes.

[6] The Pettman's fuzes were always stamped with the number of thousand, this mark therefore indicates the actual number made up to a particular date, whereas the stamping with the number of thousand was not adopted for other fuzes until 1864; nor was the system of stamping these fuzes with the *date* (in addition to the number of thousand) adopted until that year; the system of stamping the No. of the Pattern was not adopted until 1866.

[7] See what has been said, p. 77, note 1, respecting the importance of the cups being of one uniform strength, otherwise the required action may not take place.

[8] The importance of keeping the ball within strict limits as to weight will now be apparent, for evidently any increase in its weight will tend to cause the crushing of the lead cup under lighter shocks than that of the discharge of the gun and will tend therefore to make the fuze less safe; while any decrease in their weight entails the possibility of the non-crushing of the lead cup and

The position of the movable parts of the fuze, i.e. cone plug, ball and steady plug, is thus shifted to one nearer the bottom of the fuze, by so much as the lead cup has flattened, and all re-action is checked by the cup flattening round the studs of the bottom and cone plugs, these parts being thus securely riveted, as it were, to the bottom of the fuze.

The great use of the steady plug will now appear:—It serves, as its name implies, to *steady* the ball at the moment of the shock of discharge; in its absence the ball, being unsupported at the top would fall on the flattening of the lead cup on to its side, and in proportion to the violence with which the detonating composition would thus be brought into contact with the sides of the fuze would premature explosions more or less certainly result.[1]

After the shock of discharge the steady plug is of no further use; the rotation or movement of the shell disengages it from the ball,[2] which rests during the flight of the shell within the chamber of the fuze. On the shell striking an object the ball is thrown forward with a force proportional to the momentum of the shell and the violence of the shock; the detonating composition being thus brought into violent contact with some part of the interior of the fuze is exploded, and the flame passes through the fire holes in the cone and bottom plugs into the shell.

One or two points which do not properly connect themselves with a description of the construction or directly with the action of the fuze require explanation.

It has been explained that the studs on the cone and bottom plugs serve to prevent re-action, they also serve by their form to prevent the lead cup from flattening over the fire holes which would thus be closed and all communication between the interior of the fuze and shell cut off.

The reason for making the ball, cone and steady plugs of a harder alloy than the rest of the fuze is as follows: In the case of the ball, if the projections were not made of a certain strength, they would yield under the shock of a heavy discharge and premature explosion would result. The required strength can only be given by increasing the size of the projections or by making them of a stronger material. To increase the size would increase what may be considered as the dead points of the ball;[3] and the other alternative, that of making the projections and consequently the whole ball of a harder alloy, was therefore adopted.

As regards the cone and steady plugs, these if made of soft material, would be liable to yield under a heavy shock, and they are therefore brought to the requisite strength by employing a harder alloy.

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the consequent non-action of the fuze under low charges. The limits are (uncovered) from 140 to 125 grains; or (covered) from 146 to 134 grains.

[1] It must be remembered that the position of the fuze in the gun is with its longer axis, not as it has been placed throughout the above description, vertical, but horizontal; there would thus be no chance of the ball balancing itself on the cone plug in the absence of the steady plug. It would inevitably fall against the side of the fuze.

[2] See p. 82 respecting the uncertainty of action of these fuzes with B.L. rifled guns, and the causes of this uncertainty.

[3] Since being uncovered with detonating composition no action could result from the impact of one of these projections on the inside of the fuze.

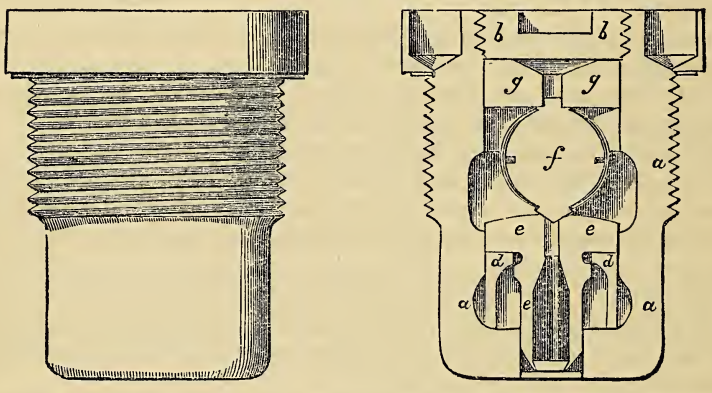
The shape of the projections on the ball is regulated by the following considerations: It is desirable that it should be such as to permit of the ball readily freeing itself, due regard being paid to the support of the ball between the plugs. Now in the case of the lower projection, the present conical form is that which permits most readily of the liberation of the ball, and at the same time affords a sufficient hold; in the case of the upper projection, however, more hold is requisite, or the ball might become freed from the steady plug under the shock of discharge, whence premature explosion might result; this projection is therefore made cylindrical.

Pettman's Land Service Fuzes can be used with all those Common Spherical Shells *which have a cross cut upon the plug*.[1]

(2) Pettman's Sea Service Percussion Fuze[2] (Figs. 3, 4) differs from the L.S. Pettman fuze principally in an arrangement by which the sensitiveness of the fuze is so exactly regulated as to bring it within the limits prescribed for naval service, viz. that the fuze shall not explode when striking water with a high velocity, while it shall explode on striking a ship's side or hard substance with a low velocity.[3]

PETTMAN'S SEA SERVICE PERCUSSION FUZE.

Fig. 3. *Full size.* Fig. 4.



This arrangement consists 1st, in placing immediately over the detonating composition on the ball two hemispherical cups of thin sheet copper,[4] the

[1] All common shells are now prepared to receive Pettman's fuze; but the existing stores of common shells which have not the cross cut upon the plug and which consequently will not receive the fuzes, have probably not yet all been converted for their reception.

[2] Approved 2nd August, 1862. W. O. C. 793, par. 610.

[3] It is sometimes considered that the sensitiveness of the sea service fuze is less than that of the land service fuze, this however can hardly be said of the case; indeed, where the direction of striking is sideways the sea service fuze is probably (owing to the enlargement of the interior) the more sensitive of the two. But the difference consists, as stated in the text, in the sensitiveness of the sea service fuze being *exactly regulated* and brought within certain limits, whereas the sensitiveness of the L.S. fuze is not so regulated or considered.

[4] The copper is rolled down to ·008″. The weight of these cups is limited to from 5½ to 6½ grs.

thickness of which has been exactly calculated with reference to the degree of sensitiveness required. (Fig. 4, *f*).

The junction of the two cups round the horizontal circumference of the ball[1] is covered with a strip of tissue paper varnished on and afterwards the ball receives the usual coverings of gut, silk, and varnish.

2nd. The interior of the fuze is enlarged about the centre so as to make the blow which the ball strikes on impact equal in all directions.[2] (Fig. 4, *a*).

Pettman's sea service fuze differs from the land service in a few other details of construction: it has no bottom plug, the bottom of the fuze being solid, with the exception of a small fire hole in the centre which is closed with a disc of cardboard, over which is varnished a disc of fine paper.

The cone plug (Fig. 4, *e*), is of an improved construction, the stud being prolonged downwards in the form of a hollow cylinder, which is driven and pierced like a tube, the lower end being closed with a cardboard disc.[3] This construction, and the absence of a bottom plug stud, necessitate a different arrangement for checking re-action: the lower part of the interior of the fuze is hollowed out or undercut, and the lead cup crushing outwards into this groove is securely held and the upper part of it having contracted round the stud of the cone plug, re-action is prevented.

Externally the sea service fuze differs in being larger and screwed to fit the fuze holes of the naval or "Moorsom" gauge.[4]

The thread instead of being carried down the whole length of the fuze, only extends $\frac{3}{4}''$ below the shoulder.

The wrench holes in the sea service fuze are further apart than in the land service fuze, being adapted to the naval wrench.

In other respects the Pettman's sea and land service fuzes are the same.

The sea service fuze is also similarly marked with the number of thousand, numeral I., and month and year of issue, and lacquered.

The action of the two fuzes is the same, with the exception that in the sea service fuze on the crushing of the lead cup, the tube of the cone plug is shot forth beyond the bottom of the fuze, forcing out the cardboard disc by

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each. It is evident that any increase in thickness will tend to render the fuze less liable to act on striking a ship's side, while any decrease in thickness will tend to make it more liable to explode on striking water, and as the limits are very restricted, great delicacy and exactness is necessary in the manufacture of these cups.

[1] In some early experiments the junction was placed round the vertical circumference, but premature explosions resulted. This was believed to proceed from the partial separation of the cups on the shock of discharge and the scraping downwards of the cups over the detonating composition. The ball of the S.S. fuze is the same size as that of the L.S. fuze, but the position of the groove is not exactly round its circumference, as such an arrangement would bring the groove at the junction of the cups. The covered S.S. ball weighs more than the L.S. ball, owing to the copper cups, the limits are from 160 to 148 grains.

[2] This is an important point where the sensitiveness of the fuze has to be carefully regulated, since, evidently, however accurately that sensitiveness might be regulated for the fall of the ball with the fuze end on, if that fall were not exactly the same when the fuze struck sideways, the sensitiveness would be proportionally affected under such conditions of striking. In the L.S. fuze where the exact degree of sensitiveness is not considered, such an arrangement is of course unnecessary.

[3] This disc serves the purpose of the quickmatch in the L.S. fuze after the gun is fired, viz. prevents the powder dust from working into the fuze.

[4] The thread is therefore right-handed, $16\frac{1}{2}$ to the inch and of the "Moorsom gauge," or, the same as that of the $7\frac{1}{2}$ and 20 seconds time fuzes, and the old Moorsom fuze.

which the fire hole is closed.[1] On the impact of the fuze against a hard substance[2] the ball is exploded and the flame flashed through the tube into the shell.

The S.S. Pettman's fuze is used with all naval spherical shells, and, "pending a decision upon the question as to the fuzes to be finally adopted for the M.L. rifled guns," with all shells for muzzle-loading rifled guns, having the "Moorsom" fuze hole.[3]

It has not been recommended for use with the Armstrong B.L. guns, because owing to the ball lying in the axis of rotation, and to the absence of any lateral movement of the shell in the bore—any lateral concussion—it has been supposed that the steady plug and ball could not be depended upon to disengage when the shell struck direct. Sufficient experiments, however, have not been made to determine this point with any certainty, and indeed it seems probable, looking to the results of such experiments as have been made, that *in practice* the fuzes would act in B.L. rifled guns in a greater majority of cases than theoretically might have been expected.

P. S. Since the above was written experiments have been made on a large scale with a Pettman "Universal fuze"—a fuze which is available with smooth-bore and rifled ordnance, both breech and muzzle-loading. The result of these experiments has been so successful that this fuze has been recommended for provisional adoption.

It would obviously be premature to furnish a detailed description of this fuze until its adoption has been formally approved and notified, and I reserve the account which I propose to give of it until it is actually in the service.

I would observe, however, that the adoption of this fuze will not make a study of the details of construction, and an acquaintance with the principle of action of the existing Pettman's Land and Service fuzes above described, less interesting or important to Artillery Officers, because (1) These fuzes may in any case be expected to be retained in use until the large existing stores are exhausted;[4] and (2) The principle of action and even the majority of the details of construction are common to the "Universal" fuze, which is in fact only the present S.S. fuze ingeniously modified to ensure action with breech-loading rifled shells, and altered somewhat in external form.

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[1] The entrance of powder dust is now prevented by the cardboard disc in the tube, see p. 81, note 3.

[2] See page 80, respecting these fuzes not acting on water.

[3] W. O. C., No. 7 (New Series), § 1117. See P.S., however, where the decision of this question is indicated.

[4] About 125,000 L.S. and 182,000 S.S. fuzes have been made.

ERRATA.

Page 77. The proportion of mealed powder in the detonating composition of Pettman's fuze is $\frac{1}{2}$ oz. not 1 oz. as stated.

„ Note 4 should be erased altogether.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON 1ST, MAY, 1866.

MAJOR-GENERAL E. C. WARDE, C.B. IN THE CHAIR.

1. THE Committee of the Royal Artillery Institution have the honor to submit to the General Meeting their Annual Report for the year ending 31st March, 1866.

From the accompanying Table, which gives the increase and decrease under the several ranks, it will be seen that the total increase of Members amounts to 44, the steady advancement of previous years being thus maintained.

RANK.	£ s. d.	April, 1865.	Additions due to promotion.	New members.	Promoted, withdrawn, and deceased.	April, 1866.
EFFECTIVE LIST.						
General and Regimental Field Officers, paying annually	1 5 0	167	+14	+ 3	— 6	178
Captains	0 16 0	390	+21	+20	—29	402
Lieutenants	0 10 0	504	0	+50	—35	519
Paymasters	1 5 0	*1	0	0	0	1
do	0 16 0	*5	0	0	0	5
Quarter-Masters	0 10 0	9	0	0	0	9
Riding-Masters	0 10 0	3	0	+ 1	— 1	3
Surgeons-Major	1 5 0	4	0	+ 1	0	5
Surgeons	0 16 0	6	0	0	— 2	4
Assistant-Surgeons	0 16 0	24	0	+ 2	— 7	19
Veterinary Surgeons	0 10 0	3	0	0	— 1	2
RETIRED LIST.						
General and Regimental Field Officers	1 5 0	23	+ 6	0	— 2	27
do. do.	0 16 0	1	0	0	0	1
do. do.	0 10 0	8	0	0	0	8
do. do.	0 7 6	7	0	0	0	7
Captains (D. W. Pack Beresford)	5 0 0	1	0	0	0	1
do.	0 16 0	16	+ 8	0	— 2	22
do.	0 10 0	4	+ 2	0	0	6
do.	0 5 0	6	0	0	0	6
Surgeons-Major	1 5 0	1	0	+ 1	0	2
Chaplains	1 5 0	1	0	0	0	1
		1184	+51	+78	—85	1228
Honorary Members	0 10 6	29	+ 9	0	— 1	37

* Included last year in list of Captains.

2. The Abstract of Accounts for the past year shews a balance credit of £1505. 0*s*. 1½*d*.

The increased expenditure for wages is due to an augmentation of the pay of the Serjeant-Major in charge. This non-commissioned officer having completed five years employment at the R.A. Institution in his present capacity in July last, during which time he has given general satisfaction, the Committee have sanctioned an increase of 1*s*. 5¼*d*. a day to his pay in consideration of length of service, and of the additional work and responsibility attaching to his position, in consequence of an increase of Members during that period amounting to one-third of the whole number.

The Committee have to regret the loss during the past year of two of the Trustees, owing to the death of Lieut.-General H. W. Gordon, R.A., and of General F. Campbell, R.A.; in compliance with Rule XI., Major-General St George, C.B., R.A., and Major-General A. J. Taylor, R.A. have been elected to fill the vacancies.

3. *Printing and Publication.*—Vol. IV. of the "Proceedings" has been completed, and one number of Vol. V. has since been issued.

The Committee have spared no pains to procure papers of interest for the Professional publication of the Regiment, and believe that the volume just completed will compare favourably with previous issues; whilst expressing their thanks to all those gentlemen who have contributed to the Proceedings during the past year, and whose names will be found in the annexed list, they desire especially to record their sense of the high merit of the two papers on "Ancient Cannon in Europe," the result of very great labour and research on the part of Lieut. Henry Brackenbury, R.A.

Since the last Annual Meeting two complete sets of the "Proceedings" have been presented to the Military and Naval officers attached to the French Embassy, and the Committee hope that having thus acceded to the request of those Officers on the part of their Government, similar information will be freely afforded by them in return.

The new edition of the "Handbook" was commenced in August, but considerable delay has arisen owing to the present transition state of artillery *matériel*, rendering it necessary for much of the book to be re-written. Three half-sheets (96 pages), have, however, been completed, and 6450 copies have been worked off. A large portion of the subsequent matter is also set up, and the Committee hope the new edition will shortly be published. Government have requested to be supplied with 500 copies of the new edition.

The Secretary of State for War has authorized the sale to Members of the Institution of the Extracts from the Reports and Proceedings of the Ordnance Select Committee, which are published quarterly, and which contain most valuable professional information. Copies can be obtained on application to the Secretary of the R.A. Institution.

The new edition of Kane's List has not been commenced, owing to a want of sufficient subscribers. The Committee are still anxious that this interesting Regimental Record should be republished, but 40 additional subscribers are first requisite.

The means at the disposal of the Institution for meeting the constant and increasing demands on the printing press by Members were so inadequate

General Abstract of the Income and Expenditure of the Royal Artillery Institution, from 1st April 1865, to 31st March 1866.

Dr.	£	s.	d.
Printing and Publication. Wages	214	19	7½
Paper	206	12	8
Type and Materials	179	11	3
Wood Cuts	68	14	0
Lithography	54	5	5
Chemistry	54	4	1½
Photography. Chemicals and Apparatus	51	16	0
Printing, Mounting, &c.	347	13	3
Drawing	70	0	3
Lectures	32	13	6
Taxidermy	6	13	0
Library, Books, &c.	209	15	3
Museum	29	1	0
Instruments	5	7	0
Carpenter. Materials	66	9	2½
Wages	18	11	0
Insurance on £5000, to 24th June, 1866	16	5	0
Furniture and Repairs	69	10	8½
Subscriptions to Societies	3	3	0
Stationery	254	10	10
Postage and Parcels	51	14	1
Wages, Clerks and Orderlies	122	14	0¾
Incidental	58	19	6
War Office Photographs	34	13	0
Cash in hand, 31st March, 1866, Secretary 22 17 0½	19	6	1½
Overdrawn on Messrs. Cox and Co. 3 10 11			
	£ 2247	2	10¼

Cr.	£	s.	d.
Cash in hand, 1st April, 1865	17	7	1¼
Dividend on £1200 Consols (to 5th Jan. 1866)	35	8	0
Subscriptions, to 31st March, 1866. Annual	910	2	0
Entrance	78	0	0
Paid in Advance	6	14	0
General Printing	310	5	9
Chemistry	53	9	1
Photography. Chemicals and Apparatus	6	19	7
Printing, Mounting, &c.	419	6	7
Drawing	39	19	0
Taxidermy	1	17	0
Library, Books, &c.	104	14	10
Instruments	1	12	6
Carpenter, Wood, &c.	26	4	4
Stationery	179	8	0
Postage and Parcels	20	6	9
War Office Photographs	34	17	9
Lectures (overpaid last year)	0	10	7
	£ 2247	2	10¼

DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1866.

Debtor	£	s.	d.	£	s.	d.
Outstanding Debts, 31st March, 1866. Printing Material	264	7	7			
Stationery	15	17	4			
Photography	6	4	4			
Library	2	4	0			
Chemistry	9	5	0	297	18	3
Overdrawn on Messrs Cox & Co.				3	10	11
Balance Creditor				1505	0	1½
				£ 1806	9	3½

Creditor	£	s.	d.	£	s.	d.
Balance. Consols Stock				1200	0	0
Cash in hand, 31st March, 1866				22	17	0½
Approximate value of—						
Books and Stationery, for Sale	130	0	0			
Printing Paper, on Stock	60	0	0			
Printed matter, including "Handbook"	100	0	0			
Chemicals (Laboratory)	20	0	0			
" (Photographical)	15	0	0	325	0	0
Amount owing by Officers. Books, &c.	31	2	8			
Drawing	7	10	8			
Photography	68	16	4			
Postage	6	8	5			
Printing	47	14	9			
Stationery	36	15	6			
Taxidermy	10	9	0			
Wood	0	19	5	209	16	9
Amount owing for back Subscriptions				48	15	6
				£ 1806	9	3½

Woolwich,
14th April, 1866.

A. HARRISON, Captn., R.A.
Secretary R.A.I., and Treasurer.

that the Committee decided to purchase a new Rotary Printing Machine whereby from 600 to 700 copies can be worked off in an hour by three men, in lieu of 150 copies, the average result of two men's labour with the old Columbian Press. The new press has only been in use since the beginning of February, and although it has already been of great service, the time is too short to enable the entire benefit to be realised, but the Committee feel confident that the outlay on this account, amounting to £119, will be fully repaid in subsequent years.

List of "Proceedings" printed during the year.

Ancient Cannon in Europe. Part I. From their first employment to A.D. 1350. By Lieut. Henry Brackenbury, R.A., Member of the Archæological Institute of Great Britain: Assistant Instructor in Artillery, Royal Military Academy.

Report on the "Genista" Cave, Windmill Hill, Gibraltar. (Published in the Gibraltar Chronicle, January 23, 1865).

Annual Report and Abstract of Proceedings of a General Meeting of the Royal Artillery Institution, held on Tuesday, May 2, 1865. Maj.-Gen. E. C. Warde, C.B. in the Chair.

Contributions to the technology of Foreign Rifled Ordnance (No. 1.), by Brigadier-General Lefroy, R.A., F.R.S.

Description of three Guns found in the Fort of Futtehgurh on its capture by Lord Clyde in 1858, by Lieut. H. W. L. Hime, R.A.

Account of the final Attack and Capture of Richmond by the Federal American Army, commanded by General Grant; by Major H. A. Smyth, R.A. (Communicated by the Deputy-Adjutant-General, R.A.)

Remarks on the Operations of the Royal Artillery during the Campaigns, in New Zealand, in 1861 and 1863–1864, by Lieut. A. F. Pickard, VC, R.H.A.

Report of the Ordnance Select Committee, on the trial of the 7″ wrought-iron Guns rifled on various systems, No. 3575, dated 21st December, 1864. (Communicated by direction of the Secretary of State for War).

Report of Ordnance Select Committee, No. 3730, dated 1st May, 1865. Competitive 7″ wrought-iron muzzle-loading Guns, 2nd Report. (Communicated by direction of the Secretary of State for War).

Report of Ordnance Select Committee, No. 3841, dated 21st July 1865. 7″ M. L. wrought-iron (competitive) Guns, rifled on different systems, 3rd Report. (Communicated by direction of the Secretary of State for War).

On the Construction of our Iron-clad Fleet, and a few remarks on Iron Shields for Coast Batteries, by Captain A. Harrison, R.A.

Causes of the Deviation of Projectiles unconnected with rifling, by Lieut. W. F. Richardson, R.E.

Ancient Cannon in Europe. Part II. From A.D. 1351 to A.D. 1400. By Lieut. Henry Brackenbury, R.A., F.S.A., Assistant Instructor in Artillery, Royal Military Academy.

Method of measuring distances of Ships from Coast Batteries by means of the Electric Telegraph. (Communicated by Captain R. W. Haig, R.A.)

4. *Library.*—The following list shews the books, plans, &c., purchased and presented during the year, and it will be seen that several valuable contributions have been received from the War Department. Two additional publications are now received periodically for the Reading Room, viz. the Practical Mechanics Magazine, and the Geological and Natural History

Repertory; several numbers of Gould's "Humming Birds" have also been received, the Committee having decided to subscribe for this work, which is published in the same admirable style as the companion works the "Birds of Asia" and "Birds of Europe" already possessed by the Institution.

Since the last Meeting the R.A. Institution has been placed on the list of Members of the Arundel Society, and the prints which have been received are stated in the accompanying list. The Society having passed some new regulations, whereby Members on payment of an extra guinea a year can receive a second set of publications of entirely new subjects, the Committee have agreed to the payment of the increased subscription.

The sale of War Office Photographs has been smaller than in previous years, which is accounted for by the issue through the Institution having been restricted to Members only, as notified in the last Annual Report.

A moderate number of Royal Carriage Department Lithographs have been disposed of, and authority has been obtained for the sale of Royal Laboratory Lithographs, price 9d. each sheet.

Books, &c. presented.

Military plans, country round Shanghai.....	15	Secretary of State for War, through the Director of Ordnance Survey.
Strength, composition, and organization of the Army of Great Britain. (3rd Edition)	2	Secretary of State for War, through the Director, Topographical Department.
Extracts from the Reports and Proceedings of the Ordnance Select Committee, Part 4, Vol. II., and Parts 1, 2, 3, Vol. III.	6	Secretary of State for War, through the Director of Ordnance.
W.O. Photographs	345	
Royal Carriage Department Lithographs...	15	
Royal Laboratory Lithographs	37	
2nd, 3rd, and 4th Addendums to the Journal of the Deputy-Assistant-Quarter-Master-General in New Zealand.....	3	
Second Report on Ballistic Experiments...	12	
Report of the Ordnance Select Committee on the Copper Bushing of the 68-pr. and other Cast-iron Guns	6	
Report of the Special Armstrong and Whitworth Committee	1	
Report of the Ordnance Select Committee on Experiments against the "Hercules" target	6	
Army Equipment, Part 6, Commissariat...	1	
House of Commons Papers—Session 1865. Nos. 13, 47, 50, 51, 59, 69, 71, 82, 85, 108, 120, 123, 128, 152, 156, 159, 166, 170, 181, 184, 186, 199		
Parliamentary Papers. Nos. 11291, 70, 106, 11154, 11279, 11813, 152, 135, 11783, 12107.....		

Armstrong guns, land service	37	The Deputy-Adjutant-General, Royal Artillery.
Report of a Professional Tour of Artillery Officers, 1864	6	
Examination Papers used at the examination of candidates for direct Commissions, 1865	3	Council of Military Education.
Examination Papers used at the examination of candidates for appointment to the Commissariat	2	
Examination of Candidates for admission to the Royal Military College, Sandhurst, June and December 1865	2	
Reports on the Examinations for admission to the Royal Military Academy, July, 1865, and January 1866	2	
Report on the Examination for admission to the Staff College, held July 1865	1	
Report of the Final Examination at the Staff College, held December 1865	1	
Examination papers, for admission to the Advanced Class of Artillery Officers	20	
Second General Report of the Council of Military Education	1	
Examination Papers, R.M. Academy, June and December 1865	2	Inspector of Studies, R.M.A.
Annual Report of Smithsonian Institution, 1863	1	Smithsonian Institution.
Meteorological Observations, 1854 to 1859	1	
Smithsonian Contributions to Knowledge, Vol. XIV.	1	
Papers 14, Vol. III., and 2, 3, 4, 6, 7, 9, 10, Vol. IV. Royal Engineer Establishment	8	The Director, Royal Engineer Establishment.
Proceedings of Royal Geographical Society, Nos. 3, 4, 5, Vol. IX.	3	The Council, Royal Geographical Society.
Journal of the Royal Geographical Society, Vol. XXXIV.	1	
Proceedings of the Royal Zoological Society of London, from 1848 to 1864, inclusive, with Index	...	Royal Zoological Society of London.
Minutes of Proceedings of the Institution of Civil Engineers, Vol. XXI. and General Index to Vols. I. to XX.	2	Institution of Civil Engineers.
Russian Small Arms Journal, Nos. 1, 2, 3, 1865.	3	Colonel N. de Novitzky.
Russian Artillery Journal, Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 1865	9	
Journal of the Royal Asiatic Society, Vols. XVII., XVIII. and XIX	3	Lt.-Gen. Sir W. F. Williams, Bart., K.C.B.
Journal of the Royal United Service Institution, Vol. VIII.	1	The Council, Royal United Service Institution.
Aquatint Sketches, taken in the Carnatic and Bengal, by Lt. James Hunter, R.A., about the year 1790	60	Brig.-General J. H. Lefroy, R.A.

Hart's Quarterly Army Lists, 1865	4	The Committee R.A. Library.
His Majesty Reviewing the Armed Associations on the 4th June 1799, in Hyde Park	1	Capt. T. A. J. Harrison, R.A.
Sketch taken at Canton, with portrait of Colonel Brereton, R.A.	1	
Geographical plan of the Island of St Helena	1	
Pamphlet on Telemeters, or instruments for measuring distances, by the late Lieut. A. H. Bell, R.A.	67	G. W. Bell, Esq.
Chalmer's Estimate of the strength of Great Britain	1	Maj.-Gen. R. Burn, R.A.
Dictionnaire Geographie	1	
Dictionnaire D'Alberti	1	
Miscellaneous Books	40	
Precis des Evenêmes Militaire, par General Dumas.....	19	Major H. P. Bishop, R.H.A.
Price list of Woolwich Military Stores, Contract, Dockyard, and Miscellaneous supplies	1	Captain H. W. Gordon, C.B., Royal Arsenal.
Colours of Double Stars	1	Admiral W. H. Smyth, K.S.F.
Photographic views of Dover and Queen Elizabeth's Pocket Piece.....	2	Captain R. Phelips, R.A.
Pamphlet "Science and Faith"	1	Rev. W. F. Hobson.
Notes on the compounds of Copper and Phosphorus, by F. A. Abel, Esq. F.R.S.	1	The Author.
Shoeburyness and the Guns, by P. Barry	1	Dr Percy, F.R.S.
Danish Infantry Exercises	1	Lt.-Colonel A. Stewart, R.A.
Professional Papers of the Corps of Royal Engineers, Vol. XIV.	1	Capt. C. S. Hutchinson, R.E.
Maps and Plans, relating to the war in the Crimea and the East	8	Colonel P. H. Mundy, R.H.A.
Photograph of Chronograph, and Report of Experiments with ditto	1	Rev. F. Bashforth, B.D.
Bowman's Chemistry. (5th Edition) ...	1	C. L. Bloxam, F.C.S.
Final Examination Papers of Advanced Class of Artillery Officers, March 1866	2	Director of Artillery Studies.
An Appeal to Parliament of 1866, on a "Turret Navy for the future," by Rear Admiral Halstead	1	Colonel E. Maberly, C.B., R.A.
The truth about Bhotan, by One who knows it.....	1	Captain C. W. Wilson, R.A.
Latin Pamphlet	1	Anonymously.

Arundel Society, Plates, &c.

1. St Sixtus giving money to St Laurence for Alms.
2. Adoration of the Magi.
3. Nativity of our Lord, and His Presentation in the Temple.
4. St John Baptist, and St Veronica.
5. Hans Memling, a notice of his life and works.

Books purchased.

Report of the Secretary of the U.S. Navy. One Vol.
The Ibis (new series), Nos. 1, 2, 3, 4. Vol. I.
Gould's Birds of Asia. Part 17.
„ „ Great Britain. Parts 7, 8.
„ „ Australia. Two Vols.
„ Monograph of the Trochilidæ, or Humming Birds. Parts 16, 17, 19, 20, 21.
Exotic Butterflies, by W. C. Hewitson. Parts 1 to 20.
List of Lepidopterous Insects in the Collection of the British Museum. Parts 1 to 6.
Catalogue of British Birds in the Collection of the British Museum. One Vol.
Elements of Geology, by Sir Charles Lyell. One Vol.
Practical Hygiene, by Dr Parkes. One Vol.
Iron Manufacture, by Fairbairn. One Vol.
Manual of Artillery Exercises. One Vol.
Pre-historic Man, by Dr Wilson, L.L.D. One Vol.
Military Bridges by Haupt. One Vol.
Engineer and Artillery operations against Charleston in 1863. One Vol.
Money, Weights, and Measures, of all nations, by W. A. Brown, L.L.D. One Vol.
Pamphlet on the New Chemical Gunpowder.
Traité de Balistique Expérimentale, by Hèlie. One Vol.
Weisbach's Mechanics of Machinery and Engineering. Two Vols.
Revue de Technologie Militaire ou Recueil International. Three Parts, Vol. III., Three Parts, Vol. IV., and Part 1, Vol. V.
Post Office London Directory, 1866.
England's Artillerymen, by A. Browne, R.A. Band.
Illustrirte Kriegs-Berichte aus Schleswig Holstein. One Vol.
The Physical Geology and Geography of Great Britain. One Vol.

List of Periodical Publications.

Journal de Mathématiques.
Journal des Armes Spéciales.
Comptés Rendus.
Crelle's Journal.
Le Spectateur Militaire.
Practical Mechanics Journal.
Philosophical Magazine.
Journal of the Society of Arts.
The Geological and Natural History Repertory.
British Journal of Photography.
The Photographic News.
Jackson's Woolwich Journal.
The Times.

5. *Museum.*—During the past year several interesting additions have been made to the Natural History Collection of the Institution. Of these the following may be named: Some bones of the Dodo *(Didus ineptus)*, presented by Major Anson, R.A.; a small collection of Indian Birds by Captain Warren, R.A., and a few British Birds by Lieut. Burgess R.A. and Lieut. Legge, R.A. The collection of British land and freshwater Mollusca presented by Asst.-Surg. Tate, R.A., are a valuable contribution, as also the reptiles and insects received from Lieut. Hughes-Hallett, R.A. from Madras, which owe the excellent state of preservation in which they were received to their having been sent home in bottles containing methylated spirit.

The Committee have purchased a few type specimens of birds from Japan which, whilst being of great interest as forming part of the first collection received in this country from that locality, were not likely to be added to the Museum by presentation.

The Mineralogical Collection has received a valuable contribution of precious stones from Ceylon, presented by Captain Nicolls, R.A.

It is to be regretted that no addition has been made to the collection of eggs during the past year; contributions both of British and Foreign specimens will be very acceptable.

A Catalogue of the valuable collection of North American Birds now in the Museum, has been compiled by Mr H. Whitely, and will be found useful to Officers studying this part of the collection.

Two additional cases, similar to those made in 1863 and which are now full, have been made at the Institution, and will afford increased accommodation for miscellaneous objects of interest.

Presentations to Museum.

Chinese map of Pekin	1	Captain W. French, R.A.
Pieces of stone from the Great Wall of China	2	Captain W. French, R.A.
Piece of Chinese pottery	1	Captain W. French, R.A.
Austrian Officer's sash	1	Lieut. E. Marshall, R.A.
Pith hat, and pair of Chinese slippers	2	Maj.-Gen. R. Burn, R.A.
Model canoes, North American	2	Maj.-Gen. R. Burn, R.A.
Pair of Canadian snow shoes	1	Maj.-Gen. R. Burn, R.A.
Book, eaten through by insects, called in Malta "silver tails."	1	Colonel S. E. Gordon, R.A.
Pair of undress staff epaulettes, prior to 1855	1	Colonel S. E. Gordon, R.A.
Part of a Russian flag of truce, and Russian boat flag, both from the Redan	2	Captain A. K. Rideout, R.A.
Officer's helmet, late Bengal Horse Artillery	1	Col. J. H. Smyth, C.B., R.H.A.
Piece of ore, containing silver, copper, zinc, and tin	1	Captain H. B. Parkin, h.p. R.A.
Indian wood fuze of native manufacture	1	Captain A. Ford, R.A.
Shells of Tiger nautilus, from Andaman Islands	2	Lieut.-Col. R. Biddulph, R.A.
Andaman bows and arrows		Lieut.-Col. R. Biddulph, R.A.
Collection of land and freshwater mollusca		Asst.-Surg. G.R.Tate, M.D.R.A.
Bottles of reptiles from Madras	3	Lieut. W. H. Hallett, R.A.
Japanese rammer head, wood bottom for shell, two besoms, and a shoemaker's clamp, found in Japanese guns on their arrival in the Royal Arsenal.	5	Lieut.-Col. R. K. Freeth, R.A.
British bird skins	4	Lieut. H. M. Burgess, R.A.
do	10	Lieut. W. V. Legge, R.A.
Death's head moth	1	Asst.-Surg. H. C. Miles, R.H.A.
do	1	Major C. J. Young, R.A.
Specimen of plumbago from Ceylon	1	Major C. J. Young, R.A.
Pair of Officer's epaulettes, prior to 1854	1	Major C. J. Young, R.A.

Pieces of Japanese paper, made of pure silk	2	Capt. C. V. Arbuckle, R.A.
Madagascar chair	1	Lieut. S. P. Oliver, R.A.
Chalk specimen from Brighton, shewing holes bored by pholas	1	Capt. T. A. J. Harrison, R.A.
Greatcoat, of Corfu manufacture	1	Capt. W. J. Wilson, R.A.
Bows and arrows, blow pipe, and poisoned arrows, from Demerara	...	Maj.-Gen. J. St George, R.A.
Bird skins from India	22	Capt. F. G. E. Warren, R.A.
Bones of Dodo from Mauritius	...	Capt. A. E. Anson, R.A.
Officer's breastplate, late Madras artillery	1	Major J. Hoyes, R.A.
1 topaz, 2 moonstones, 2 cinnamon stones, 1 amethyst, 1 tourmaline, 1 tourmaline topaz, 4 pearls	12	Capt. O. H. A. Nicolls, R.A.
Models of boats in use off the shores of Ceylon	10	
Mineral specimens—		
Red Hæmatite	2	Capt J. E. Blackwell, R.A.
Clay iron ore		
Specimens of coral	2	Capt. J. L. Clarke, R.A.
Shells	4	
Chinese brass fuze	1	Capt. R. E. Cane, R.A.
Large iron spike, as used for captured Chinese guns with enlarged vents	1	

Birds from India, presented by Captain Warren, R.A.

Pericrocotus flammeus.
Parus jerdoni.
Siva, strigula.
Mycerobus melanoxanthus.
Garrulax variagatus.
Muscipeta paradisi.
Merula castanea.
Merula boulboul.
Turdus viscivorus.
Temnurus vagabundus.
Palæornis schisticeps.
Megalæma virens.
Cuculus micropterus.
Gecinus occipitalis.
Janthia cyanura.

British Birds, by Lieut. Burgess, R.A.

Syrnium aluco.
Numenius arquata.
Gallinula chloropus.
Uria troile.
Rissa tridactyla.

British Birds, by Lieut. Legge, R.A.

Syrnium aluco.
Corvus corone.
Charadrius hiaticula.
Cinclus interpres.
Tringa alpina,
Calidris arenaria.
Colymbus septentrionalis.
Podiceps minor.
Larus argentatus.
Larus canus.

Type specimens of Birds from Japan (Purchased).

Milvus melanotis.
Parus minor.
Parus ater.
Alauda japonica.
Motacilla lugens.
Certhia familiaris (var. japonica).
Fringilla montifringilla.
Passer montanus.
Pyrrhula orientalis.
Emberiza personata.
Corvus japonensis.
Fuligula clangula.
Podiceps cristatus.
Larus occidentalis.
Graculus.

British Insects, by Major Young, R.A., and Asst.-Surg. Miles, R.A.

Two specimens of Acherontia atropos.

British Land and Freshwater Mollusca, by Asst.-Surg. Tate, M.D., R.A.

Octrina pellucida.
Zonites cellarius.
„ alliarius.
„ nitidulus.
„ radiatulus.
„ purus.
„ crystallinus.
„ lucidus.
Helix aspersa.
„ arbustorum.
„ nemoralis.
„ „ *var.* hortensis.
„ virigata.
„ caperata.
„ ericetorum.
„ hispida.
„ sericea.
„ aculeata.
„ lamellata.
„ pulchella.
„ „ *var.* costata.
„ rotundata.
„ pygmaea.
„ obvoluta.
„ cantiana.
„ lapicida.
„ rufescens.
Bulimus obscurus.
„ montanum.
„ acutus.
Zua lubrica.
Azeca tridens.
Succinea putris.
„ „ *var.* gracilis.
Pupa umbilicata.
„ museorum.
„ edentula.
„ pygmaea.
Carychium minimum.
Physa fontinalis.
„ hypnorum.
Conovulus denticulatus.
„ bidentatus.
Lymnaeus pereger.
„ „ *var.* ovatus.
„ stagnalis.
„ truncatulus.
„ palustris.
„ auricularius.
Ancylus fluviatilis.
Planorbis crinatus.
„ glaber.
„ albus.
„ spirorbis.
Cyclas cornea.
Pisidium amnicum.
Cyclostoma elegans.
Bithinia tentaculata.
Paludina vivipara.
Valvata piscinalis.
Neritina fluviatilis.

Presented by Captain J. L. Clarke, R.A.

Two specimens, Voluta musica.
One „ Mitra episcopalis.
One „ Red coral.

6. *Taxidermy.*—The Committee are glad to be able to report that since the commencement of this year a class of Officers has met regularly twice in each week to receive instruction from Mr Whitely in preparing and setting up birds. This instruction is now given gratuitously to Members, and as six lessons will enable any Officer to acquire all the knowledge which is requisite for skinning birds, it is to be hoped that advantage will be taken of this class by Officers before they go abroad, as the Committee believe that by this means donations from Foreign Stations will have more frequently to be acknowledged than heretofore.

7. *Classes.*—The Classes for the study of French, German, and Drawing have met as usual, and the latter has been very well attended.

8. *Surveying.*—Captain Drayson has attended twice weekly to give instruction in Surveying and Practical Astronomy. Several Officers have acquired facility in Military Sketching, and some practical knowledge of Astronomy.

9. *Photography.*—The Photographic department of the Institution has been very serviceable; a few Officers have received instruction in Photography, and over 12,400 copies have been printed from the negatives taken during the year.

A pistol camera has been purchased to enable instantaneous photographs to be taken.

The Committee have to thank Captain Brackenbury, R.A. and Captain J. Lardner Clarke, R.A., for the loan of some photographs of engravings from old masters for copying. Members can procure copies of those which have been taken.

10. *Chemistry.*—The Laboratory is in excellent working order, and has been in constant use by the classes of Officers under the Director of Artillery Studies.

11. *Lectures.*—Lectures have been delivered weekly in the Theatre of the Institution by Mr Bloxam, F.C.S. on General Chemistry, and by Dr Percy, F.R.S. on Metallurgy. The following list contains a statement of Evening Lectures which have been given during the past winter; and the Committee have to express their thanks to Mr Bloxam, Lieut. H. Brackenbury, R.A., Captain Drayson, R.A., Mr Ruskin, and Mr Warington Smyth who kindly placed their services gratuitously at the disposal of the Institution.

Charles Salaman, Member of the Council of the Musical Society of London	Italian Opera: from its origin to the present time.
Warington Smyth, M.A., F.R.S., Professor of Mining and Mineralogy, Royal School of Mines.....	The occurrence, consumption, and duration of coal.
Charles L. Bloxam, F.C.S., Professor of Chemistry, Advanced Class, Royal Artillery, and Lecturer R.M. Academy	The fire-damp of coal mines.

John Ruskin, M.A.	On the relation of war to other arts.
Lieut. H. Brackenbury, R.A., F.S.A., Assistant Instructor in Artillery, Royal Military Academy	Warfare in the Middle Ages.
Frank Buckland, M.A., F.Z.S.	Oyster culture by natural and artificial means in England and France.
Captain Drayson, R.A.	On the measurement of space and time.
Rev. Alex. J. D. D'Orsey, B.D., English Lecturer at Corpus Christi College, Cambridge, and Lecturer in Public Reading at King's College, London	On Correct Public Speaking.

12. Thanks are due to Captain C. LeMesurier, R.A, for some excellent photographs of Corfu, kindly presented by him, as an addition to the collection of views of Foreign Stations, and to which Officers are invited further to contribute.

13. *Model Room.*—The Laboratory specimens referred to in the last Annual Report have been received, and the Committee gratefully acknowledge that the liberality of H.M. Government have enabled them thus to render useful one of the most instructive features of the Institution. The thanks of the Committee are also due to Captain Majendie, R.A., Assistant Superintendent, Royal Laboratory, for assistance given in classifying the specimens.

Presentations by Lieut. E. Marshall, R.A.

Bullet, Austrian infantry, prior to 1863	1
do do shewing method of compression	1
do Podewd's, introduced for Austrian infantry, in 1863	1
do Timmerhan's (Belgian)	1

List of Service Projectiles, &c., presented to the Institution, by H. M. Government.

Adapters, fuze, "Boxer"			1
Bursters, iron, filled, coal dust, 6-pr.	whole		1
	section		1
Cartridges, S.A. ball, musket rifled, coal dust,	W. Richard's B.L., 70 grs.	in water proof bags	10
		not in do.	1
	Whitworth's, 75 grs.	in water proof bags	10
		not in do.	1
Fuzes, percussion, Armstrong, pattern, Dyer's		complete	1
		section before firing	1
time, wood, Boxer, 2″ R.O.		complete	1
		section	1
Life-buoy apparatus portfire fixed to plate			1
Match, quick			oz. 3
Pins, iron, rocket, life-saving			1
Plugs, metal fuze hole	Shell "A" with string loops	large	5
		small	1
	shot, hollow, 7″ B.L.		1

- Plugs, metal shell fuze hole.
  - diaphragm 1
  - naval 2
- Portfires,
  - miners 1
  - slow blue 1
- Rockets, life-saving, 12-pr.
  - whole 1
  - section 1
- Rockets, war,
  - Boxer's 12-pr.
    - whole 1
    - section 1
  - Hale's 24-pr.
    - whole 1
    - section 1
- Shells, Armstrong
  - common,
    - 64-pr.
      - whole, empty 1
      - section filled with adapter and Boxer R. O. time fuze 1
    - 40-pr.
      - whole, empty 1
      - section, filled with adapter and Boxer R. O. time fuze 1
  - segment,
    - 64-pr.
      - whole empty 1
      - section filled with pillar fuze 1
    - 12-pr.
      - whole empty 1
      - section empty with plug ... 1
- Shells, 64-pr. M.L.
  - common
    - whole empty 1
    - section, filled, with adapter and Boxer R.O. time fuze 1
  - segment
    - whole, empty 1
    - section, filled, with plug 1
- Shells.
  - diph. shrap. riveted teak, gun. 100-pr.
    - section empty with plug but without ball 1
    - whole empty 1
    - section filled with fuze 1
  - naval riveted, to tops, 150-pr.
    - section filled, with Pettman's fuze 1
    - whole empty 1
- Shells, naval, riveted to tops, 100-pr.
  - whole empty 1
  - section filled with Pettman's fuze 1
- Shot
  - Armstrong, service, 64-pr.
    - whole 1
    - section 1
  - hollow 7″ B.L.
    - whole 1
    - section with plug ... 1
- Shot,
  - case, gun ...
    - 150-pr. 1
    - 100-pr. 1
  - loose, solid
    - 150-pr. 1
    - 100-pr. 1
- Stands, wood 24
- Sticks, rocket "Boxer" 12-pr. 1
- Stick, rocket, life-saving 1
- Washers for rockets, life-saving,
  - india-rubber 2
  - metal 1

14. *Turning.*—The old turning lathe has been exchanged for a lighter one, more appropriate for use at the Institution where steam power is not available, and authority has been granted for the requisite supply of wood to be obtained on demand from the Royal Carriage Department.

In compliance with Rule V. the following Officers retire from the Committee, and are not eligible for re-election :—

Colonel Gordon, Major Owen, Captain Lluellyn.

The following Members have also left the Garrison, and the vacancies thus occasioned have been filled up by the Committee, subject to the approval of the General Meeting :—

Colonel Middleton, C.B.	by	Colonel Wodehouse, C.B.
Lieut.-Col. Austen,	,,	Colonel C. V. Cox.
Major Lukin	,,	Major Hickes.
Lieut. Chambers	,,	Lieut. Sladen.
Lieut. Marshall	,,	Lieut. Walkey.

The following Resolutions were passed :—

1. *Proposed by Maj.-Gen. E. Warde, C.B., seconded by Colonel Wodehouse, C.B. and carried,—*

"That the Report of the Committee be adopted and printed."

2. *Proposed by the Committee and carried,*

"That the following addition be made to No.* 1. of the Rules and Regulations of the Royal Artillery Institution :—

" but on leaving the service require re-election should they wish to continue Members of the Institution."

3. A vote of thanks was passed to the Secretary.

The following Officers were elected to serve on Committee, viz :—

Captain Arbuckle, Captain Traill, Captain Anley.

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* 1. All Officers of the Regiment are eligible to become Members, upon payment of the Annual Subscription of their rank, and an entrance subscription of £1.

The Committee for the current year will stand thus:—

PATRON AND PRESIDENT:

Field Marshall H.R.H. the Duke of Cambridge, K.G.

VICE PRESIDENTS:

The Commandant.
The Deputy-Adjutant-General.

MEMBERS:

The Assistant-Adjutant-General.
The Secretary Ordnance Select Committee.
The Brigade-Major.
The Director of Artillery Studies.

Colonel W. B. Gardner.
,, Wodehouse, C.B.
,, Younghusband.
,, C. V. Cox.
Surg.-Major Litle, A.B.
Captain E. J. Bruce.
,, C. V. Arbuckle.
Major Hickes.

Captain Traill.
,, F. A. Anley.
,, R. Sandham.
,, Molony.
Lieut. Sladen.
,, J. M. Murray.
,, R. Walkey.

Captain T. A. J. Harrison, *Sec^y. and Treasurer.*

(Signed) E. C. WARDE, Major-General.
Vice-President, in the Chair.

May 1, 1866.

THE RUSSIAN IRON-CLAD FLEET.*

We have already given our readers during last year some details of our iron-clad fleet.† Having a design to refresh the memory and complete our general information, we present a sketch of the said fleet.‡

List of Vessels composing the Iron-clad Fleet.

No.	Description.	Name.	No. of guns.	Horse-power.
1	Frigate	"Sebastopol"	28	800
2	"	"Petropavlosk" (Peter and Paul)	24	800
3	Floating Battery.....	"Perveniec" (First born)	16	300
4	" "	"Ne tron mene" (Touch me not)	17	450
5	" "	"Kreml" (Kremlin)	14	360
6	Boat with 2 Turrets	"Smerch" (Waterspout).....	2	206
7	" " 1 "	"Koldun" (Wizard)	2	190
8	" " 1 "	"Wieshchun" (Monitor)	2	190
9	" " 1 "	"Uragan" (Hurricane)	2	190
10	" " 1 "	"Tifon" (Typhoon).....	2	190
11	" " 1 "	"Iedinorog" (Unicorn)	2	190
12	" " 1 "	"Strelec" (Sharpshooter)	2	190
13	" " 1 "	"Bronienositz" (Armour-bearer)	2	190
14	" " 1 "	"Latnik" (Man in armour)	2	190
15	" " 1 "	"Perun" (Thunderbolt).....	2	190
16	" " 1 "	"Lava" (Lava")	2	190

Consequently, our iron-clad fleet is composed of 16 boats having 121 guns of immense calibre and upwards of 4800 horse power.

Wooden Vessels. Iron-plated.

The iron-plated frigates, "Sebastopol" and "Petropavlosk," 1st class boats, built of timber, were transformed before completion into iron-clads.

1. The construction of the "Sebastopol" was commenced at Cronstadt, on the 7th September, 1860; she was put on the stocks on the 16th March, 1861, and on the 16th October, 1863, was taken from the North Petrovski Dock into the South Dock, where the iron plating was commenced, and was completed by the end of July, 1864. Finally, she was launched on the 12th August, and on the 8th October left the port to prove her machinery.

* For the information contained in this paper the Committee are indebted to Lieut.-Colonel de Novitzky, Military Attaché to the Russian Embassy.

† "Military Magazine," No. 6, 1864.

‡ "Naval Magazine," No. 1, 1864.

The following are the dimensions of this frigate:—Length, 300 ft.; width, 52 ft.; thickness of plates, 4½ in.; draught of water when fully equipped, 25 ft. The iron plates were obtained from England, and a portion were prepared at the Ijorske Works. Number of plates, 314; weight about 860 tons, or 53,320 poods. Thickness of teak lining 6 to 10 inches. Across the bows of the frigate, for protection from raking shot, a partition is erected, with portholes for the guns provided with shutters. The engine is of 800 horse power, constructed at the Ijorske Works. The approximate cost of the transformation of the frigate with armour-plates and labour, is nearly 990,000 silver roubles.* The machinery without fitting cost 312,201 silver roubles. The total cost of this frigate, according to the statement given, exceeds 2,000,000 silver roubles.

2. The building of the frigate "Petropavlosk" was commenced on the 12th January, 1861; she was put on the stocks on the 9th September, and it was decided on the 29th October to transform her into an iron-clad. This frigate was built according to the drawings of the "Sebastopol," and the following are her principal dimensions:—Length, 298 ft.; width about 86 ft.; thickness of armour-plate, 4½ in.; the middle water-mark, 24 ft. The iron plates were obtained from England, and partly prepared at the Ijorske Works. Thickness of teak lining, from 5 to 10 inches. It was resolved to arm her with twenty-four 8-inch steel rifled guns. At the bow, on deck, is placed a parapet with two portholes for six chase-guns, and behind the mainmast is a turret covered with armour-plate for the captain and steersman, with openings for musketry. The machinery of this frigate is of 800 horse-power, constructed at the works of Mr Baird, in St Petersburg. The cost, with armour-plates and transformation, was 1,420,113 silver roubles, and the machinery cost 420,570 silver roubles.

Floating Batteries.

3. The iron-clad battery "Perveniec" was built at the Thames Iron Works, launched from the dock the 6th May, 1863, and delivered at Cronstadt the 5th August, 1863. The principal dimensions are:—Length, 220 ft.; width, 53 ft.; water-mark, 14½ ft.; thickness of armour plates, 4 to 4½ in.; prepared at the Thames Iron Works. This battery is armed with sixteen 8-inch guns, and at the bows a ram is constructed. The engine is of 300 horse-power, and was constructed by Messrs Maudsley, Sons, and Field. The cost of the "Perveniec" was 978,978 silver roubles.

4. The iron-clad battery "Ne tron mene" was constructed in St Petersburg, on the Galerny Island, by an English engineer, Mr Mitchel. The construction was commenced on the 18th January, 1863, and the battery was launched on the 11th June, 1864. The principal dimensions are:—Length, 220 ft.; width, 53 ft.; water-mark, 16 ft. She was constructed, with slight alterations, on the model of the "Perveniec." The armour plates were made at the works of John Brown & Co., Sheffield;

* Silver rouble = 3s. 2d.

their thickness is from 4 to 4½ inches, lined with East India teak. The engine is of 450 horse-power. She is armed with seventeen 8-inch guns. Total cost 802,220 silver roubles.

5. The iron-clad battery "Kreml." The order to construct this battery, by Russian manufacturers, was issued on the 19th November, 1862. The builders were Messrs Semiannikoff & Poletika, owners of the Neva Foundry and Machine Works, in St Petersburg, who commenced construction on the 20th September, 1863. The principal dimensions are:—Length 221 ft.; width, 53 ft.; thickness of armour plate, made in England, from 4 to 5½ in. The machinery is of 360 horse-power. It was intended to arm this battery with fourteen 8-inch rifled guns, and she was ready for use on the 1st July, 1864.

Turret Boats.

The double turret iron-clad boat "Smerch" was constructed by Mr Mitchel, in St Petersburg, on the Galerny Island, according to the system of Mr Kolza. The construction was commenced on the 7th August, 1863, and the boat was launched on the 11th June, 1864. The principal dimensions are:—Length, 183 ft. 5 in.; width, 14 ft. 3 in.; watermark, 10 ft. 6 in.; and rises from the water only a few feet. There are two turrets on deck, each 22 ft. diameter, with elliptical portholes for guns. Between the fore turret and the funnel stands an oval house for the captain. The foundations of the turrets and the mechanism for turning are concealed under the deck and protected from the enemy's shot. At the bow is constructed a sharp spear-pointed ram, 4 ft. from the surface of the water. The stern is protected by overhanging armour-plates covering the rudder and screws. To decrease the rolling of the boat two additional keels are fitted below water. The armour plates, made in England, are from 4 to 4½ inches thick, and the armour of turrets is 4½ inches thick laid on a teak lining, covered inside with iron plates 1 inch thick. The deck is also covered with similar plates. The engine is of 200 horse-power, made in London, at the works of Messrs Maudsley, Sons, and Field. Besides this there is a small engine of 6 horse-power for working the ventilators for the cabins, and for turning the turrets. This boat is fitted with two screws of 8 ft. diameter. Each of the turrets is mounted with one 8 in. rifled gun. The cost without extra expenses is 504,000 silver roubles.

Single Turret Boats, or Monitors.

Circumstances requiring the rapid construction of iron-clad boats for coast defences, obliged us to adopt the American system of monitors, as they answered the chief object and offered the possibility of rapid construction.

This system of single turret boats presents two principal parts, the lower being in the form of flat-bottomed boats and the other presenting a plane with sharp projecting points to cover, at the bow, the pit for the anchor, and at the stern the rudder and screws. The bulwarks of the boat are covered with oak and pine timbers 39 inches thick, and these are covered with 1-inch armour plates in five layers. The height of the boat from the water is not more than 14 inches, and presents an unimportant mark to the

enemy's fire. The projection at the bow may if required be used as a ram. The interior of the boat is divided into six shot-proof compartments; in the first compartment, at the stern, is a telegraph battery and place for mechanical tools; in the second the machinery and boilers; in the third, coals; in the fourth the machinery for turning the turrets, and also the store-room; in the fifth are accommodation for men and officers, and the powder room, and in the sixth the capstan. On the deck about the middle of the boat is the turning turret with two guns, and inside it is a fixed house, in the form of a turret, for the steersman and the captain of the boat.

These two turrets are made of iron plates 1 inch thick, the first of 11 and the second of 8 plates. The deck is covered with two layers of ½-inch iron plates, placed in some boats above, and in others under the deck. The funnel rises 8 feet from the deck, covered with six layers of 1-inch plates. The principal dimensions of this boat are,—Length on the deck with armour plates, 201 ft.; the greatest width 46 ft.; water-mark 11½ ft. The inside diameter of the turret is 21 ft., and its height 9 ft. The machinery is of 160 horse-power, and there are also two engines, one of 15 horse-power for the two ventilators, and the other of 15 horse-power for turning the turret, which are both supplied with steam from the boilers of the principal engine.

The screws are four-bladed, 12 ft. in diameter; the rudders are balance-rudders, and the anchors are of a peculiar construction—short and with four forks. Each of the monitors has three small boats, of 10, 6, and 2 oars. Each of these monitors is armed with one 15-inch cast-iron gun and one 9-inch steel rifled gun.

The following ten boats are now being constructed on the above model, but with some slight alterations:—

No.	Name of boat.	Place of construction.	When commenced.	When finished.
1	"Bronienositz"...	Baltic Mechanical Works and Foundry, belonging to Messrs Carr & Macpherson	5th June, 1863.....	10th or 12th March, 1864.
2	"Latnik"			
3	"Wieshchun" ...	Seraing, in Belgium, by the Belgian Co., Cockerill & Co., where the parts were prepared, and put together at the wharf of the Gutuevskavo Island.....	15th June, 1863	26th April, 1864.
4	"Koldun"			
5	"Strelec"	At the Galerny Island, by Mr Kudraftseff.....	1st June, 1863.....	21st May, 1864.
6	"Iedinorog"			
7	"Uragan"	At the New Admiralty, by the Government	26th June, 1863.....	15th May, "
8	"Tifon"			4th June, "
9	"Lava"	At the Neva Mechanical Works of Siemianikoff & Poletika	15th June, 1863.....	27th May, "
10	"Perun"			28th June, "

Consequently the first launched boats were "Bronienositz" and "Latnik," which were constructed in the short time of nine months. The average complement of these monitors consists of 95 men: thus, 7 officers (2 naval officers, 1 steersman, 2 engineers, 1 officer of the corps of naval artillery, and 1 midshipman), and 87 men, including stokers and mechanics.

The Practical Sailing of Iron-clad Vessels in 1864.*

Having shewn above the composition of our iron-clad fleet, we shall now say a few words about the trial trips of this newly constructed fleet. This first trial of our iron-clads presents an interest and signification greater than ordinary practical essays, as our seamen appeared for the first time in their new task of managing iron-clads. We see here then not only the repetition of exercises in the art, already firmly established on experienced naval principles, but also a creation and adoption of new methods governed by the originality of a task scarcely commenced by the first-class European fleets.

On the formation of the complement of men for the iron-clad fleet, attention was first given to the selection of suitable commanders and their assistants, and afterwards to the formation of the crews, which were chiefly composed of men on unlimited furlough, and consequently old and experienced seamen.

The required number of artillerymen and mechanics was completed by men from other war vessels.

At the end of the winter 1863-64, the formation of the crews was finished and their instruction commenced.

By the nature of the work and the exclusive object of the iron-clads (excepting iron-clad frigates), the working of sails, which in old men-of-war was the principal object in the instruction of a sailor, was considered as of secondary importance, and attention was chiefly directed to artillery practice.

The war vessels of our time, as remarked in the review, must be considered as a special branch of artillery, each one from a war point of view being a complete arm of artillery, and being a moveable battery of a certain number of guns, consequently the first condition required from an efficient war vessel is that it should possess amongst its crew a sufficient number of good artillerymen.

It is also of the utmost importance to have good riflemen, the greatest number of whom should be able to use boarding weapons. A considerable part of the remaining men should be well trained for infantry service and equal to land forces, and finally, it is indispensable to have a sufficient number of men for the mechanical work and as attendants.

During the winter season they proceeded to take instruction in artillery service, for which purpose a wooden turret was constructed in the gymnasium of the chief admiralty in St Petersburg.

By this means 430 men were taught the artillery service required for the turrets of monitors, which number was destined to form the crews of eleven turret boats (in double sets). At the same time two books were prepared, entitled, "Instruction in Artillery Service," and "Description of Turret-Boats," fixing the exact complement of such boats. The captains and

* We include here a short extract from the Review "Trials of Practical Sailing of Iron-clads in 1864," by His Majesty's Admiral Lichatcheff. See "Naval Magazine" (Morskoi Sbornick), No. 2, 1865.

officers took part in this instruction of their intended crews, and moreover became thoroughly acquainted with the peculiarities of iron-clad vessels.

A special description of the sailing and exercising of these iron-clad boats, which was partly compiled during the year of 1864, was prepared.

We shall not enter here into details, but will only mention the principal and most interesting results, and consequently we shall first give information relating to the sailing capabilities of the boats.

According to the opinion of the commander of the squadron, founded on experience, the boats of our iron fleet, built for the sole object of coast defence (with the exception of the frigates which can make longer voyages), are at least capable of appearing at the first requisition upon all points of the coast and generally upon the whole of the Baltic sea and adjacent waters, which opinion is highly satisfactory. During the trials of the sea-worthiness of the boats, special attention was directed to their buoyancy, speed, powers of turning rapidly, and to the efficiency of their machinery. Upon these points, in the absence of data, no special results were obtained, but partial observations were taken of the performances of the respective boats. Thus, in the floating battery "Perveniec" want of sufficient buoyancy was noticed, but this, however, can be increased. The speed of the said battery was from 7 to 9 knots (12 to 16 versts), and the highest speed obtained was $10\frac{1}{2}$ knots (19 versts). It required 6 to $6\frac{1}{2}$ minutes to turn her round in a circle of 150 fathoms diameter. Her engines were excellent. With regard to the monitors, it was observed that they possessed sufficient stability. Their speed was from 6 to 7 knots (10 to $12\frac{1}{2}$ versts), and the highest speed obtained was 9 knots. Their turning powers were excellent, only occupying 4 to $4\frac{1}{2}$ minutes in a circle of 60 to 65 fathoms diameter (equal in this respect to the efficiency of screw boats). Their engines were excellent.

The next experiments and exercises were made on a system of a concentrated cannonade, and on the mode of aiming and firing the guns placed in the turrets of the monitors, at the command of the captain stationed in his deck-house.

Observations were also made relative to the compasses, and attention was drawn to the hygienic condition of the iron-clads. The cannonade was perfectly successful, and the preparations for battle were made with all necessary celerity. Thus the turret boat "Koldun," ten minutes after the alarm was given, notwithstanding the complication of the work, succeeded in completing her preparations for battle, weighed anchor and stowed it, loaded the gun, turned the turret in the proper direction, and fired the first shot, striking the centre of a small target measuring 4 fathoms × 3. The following shots were likewise successful:—Out of four shots made while the boat was in motion three struck the target at a distance of 3 to 4 cables' length (300 to 400 fathoms). In general it was found indispensable, after these experiments were made, to make additions and improvements in several parts. Rules for the disposition of the iron-clads for the defence of Cronstadt and regulations for sea evolutions were established at the same time, and the code of naval signals was revised and corrected.*

* With this view a Commission was instituted, under the Presidency of Admiral Lichatcheff, one of the suite of His Imperial Highness, in which Commission, as representative of the War Department, was included a Member of the General Staff of Engineers.

It was stated at the conclusion of the "Review" that as regards the invulnerability and powers of resistance of the iron-clads—that is, their real importance in war—this experimental navigation can give no positive information; their action in real warfare can only show how far these iron-clads will answer the purpose for which they are intended; but on a closer acquaintance with them and on comparing them with various classes of similar boats existing in other countries, we can justly conclude that we may be satisfied with them.

Our iron-clads, which were projected with a definite practical view, belong chiefly to two types, which according to local conditions are most convenient to us.

The gradual development of the turret system, even in those fleets where it was at first unconditionally refused, sufficiently proves that we have not been mistaken in permitting its adoption in our fleet.

Floating batteries, without possessing the sea-worthiness of foreign iron-clad frigates and being incapable of long voyages, are yet able to appear without any inconvenience, in all parts of the Baltic sea, and being armed with a considerable number of heavy guns, completely fulfil their end.

The "Review" proceeds to discuss the progressive improvements made in the construction of iron-clads, and justly remarks that the transition period of the naval art is not yet terminated; the recent successes in artillery practice, and particularly the perfection attained in striking the enemy's vessel below the water-mark, with the introduction of rams and torpedoes, threaten a change in the present construction of war vessels, and the modern iron-clads may in their turn disappear and be replaced by other constructions, as have the war vessels with sails, steam paddle frigates, and lastly screw men-of-war and frigates, which seemed but recently the perfection of naval art. Hence it follows that we must not in the future limit ourselves to the construction of a powerful iron-clad fleet for the defence of our Baltic coast, although for the present, according to the opinion of the "Review," our said fleet, with the artillery it is capable of carrying, is sufficient for the protection of the coasts nearest our capital and for our naval importance in the Baltic.

From *The Practical Mechanic's Journal*, February, 1866, it appears that the following are the dimensions of the principal ships now in course of construction for the Russian government:—

"The largest is the 'Pojarski,' an armour-clad vessel about 280 ft. long, 49 ft. beam, and about 31 ft. deep. The armour-plating is 4½ inches thick, and extends the entire length of the vessel from the depth of 5 ft. below, and 6 ft. above the line of flotation. This armour is laid on a backing of East India teak 18 inches thick. The 'Pojarski's' armament is placed in a central battery occupying about 80 ft. on the length of gun deck, both sides and ends being completely armour-clad. The armament will consist of eight 300-pr. steel guns, four on each broadside. The iron hull is of

great strength, being constructed on the cellular tubular principle. The entire bottom of the vessel is built with double iron skin, for the purpose of giving great additional safety as well as strength. The 'Pojarski' will be propelled by engines of 700 horse-power, which are being constructed with all the modern improvements for economy of fuel. Messrs Mitchel are also building for the Russian government two armour-plated turret ships on Captain Coles' system. These vessels are of 1500 tons and 250 horse-power. Each will be armed with two revolving turrets carrying a pair of 300-pr. guns. Each vessel is thus enabled to deliver a broadside of 1200 lbs. Their defensive powers are also great, as their sides from stem to stern are covered with armour 4½ inches thick, on a teak backing 18 inches thick. The entire deck is also covered with iron plating 1 inch thick. The turrets are covered with 5½-inch armour on 24-inch thickness of teak."

REPORT OF AN EXPERIMENT CARRIED ON AT SHOEBURYNESS, ON THE 21st JUNE AND 7th DECEMBER, 1865, BY THE ORDNANCE SELECT COMMITTEE.

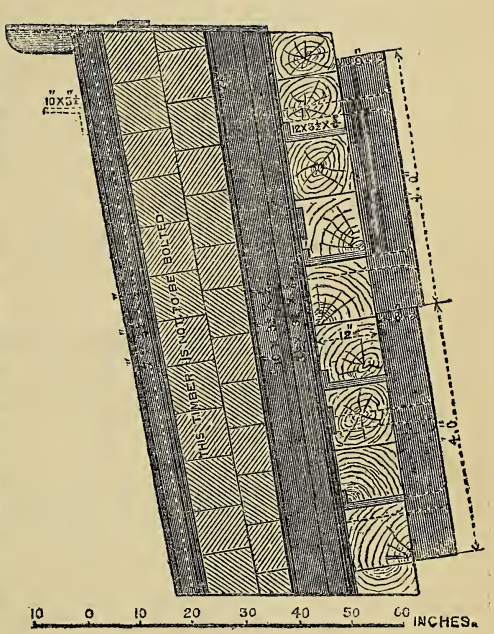
[Communicated by direction of the Secretary of State for War].

(1) To test the powers of resistance of the "Hercules" target No. 26, when attacked by the most powerful guns at present known.

(2) To ascertain the relative penetration of shot cast in chill, and steel shot when fired from the same gun, with similar charges.

The target 18′·2 × 8′ was constructed by order of the Lords Commissioners of the Admiralty, and represents the construction about to be carried out for the protection of the iron-clad "Hercules" in the neighbourhood of the water line.

The upper half of the target is faced with 9″ of iron, the lower half with 8″, behind both plates is 12″ of horizontal timber divided by 4 horizontal iron plates, then a skin consisting of two ¾″ plates; the whole being secured to the ribs which are 10″ deep filled in between with vertical timber. Behind the ribs are two linings of horizontal timber 18″ deep, not bolted, but confined by 7″ iron ribs inside all.



Thickness at bottom exclusive of the 7″ ribs, 47¼″, at top 51¼″. The bolts are 3″; those on the left section are of Major Palliser's design; those on the right are of the ordinary form.

The 9″ and 8″ plates were manufactured by Messrs Cammell and Co., of Sheffield.

The weight of the structure per square foot is about 689 lbs. for 9″ plate; 652 lbs. for 8″ plate; or double the weight of the "Warrior" target.

The guns used in this experiment were as follows:—

On the 21st June.

One 10″·5 shunt rifled gun of	12½	tons,	Experimental No.	203,	range 200 yards.
One 10″·	12	tons,	"	245,	"
One 9″·22	12½	tons,	"	222,	"

On the 7th December.

One 13″ shunt rifled gun of 23 tons, Experimental No. 300, range 700 yards.

The following shot and shell struck the target :—

From	Nature of projectile.	Weight.	Charge.	$\frac{WV^2}{4480\,g}$ Foot tons on impact.
		lbs.	lbs.	
10″·5 gun ...	1 steel shot	299·5	45	3390
	1 do	〃	45	3422
	1 do	〃	60	4221
10″ 〃	1 do	282	55	3835
9″·22 〃 ...	1 do	221·5	44	3238
	1 do	〃	44	3234
13″ 〃 ...	1 chilled shot	225	50	3195
	1 steel shot	573	100	6388
	1 do	〃	100	6480
	1 chilled shot	578	100	6872
	1 do	—	—	6872
	1 do	—	—	6872
	1 steel shell	568	100	6480
Total...	13	5296·5	—	64,499

Table of Effects.

No. of round.	Photographic No.	Nature of gun.	Projectile. Nature and weight.	Projectile. Length and diameter.	Charge.	Elevation.	Range.	Effects. Depth of indent.	Effects. Diameter of indent.	Velocities.	Remarks.
				in.	lbs.	′	yds	in.	in	ft.	
1	1040	9″·22	Elongated steel shot lbs. 221·5	13·44 *l* 9·15 *d*	*44 †	20	200	4·5	...	1503*i*‡ 1452*s*§	Struck on 9″ plate, close to a rib 13″ from top and 21″ from left side. Indent and buckle 5″·47 over 40″. Plate broken over an area of 30″ on top. Armour plate driven into wood backing; crack 9″ long and 4″ deep at 11″ left of shot hole. A Palliser bolt 2″·5 left of shot hole uninjured.
2	1041	10″·5	〃 299·5	14·05 *l* 10·43 *d*	45	18	200	8	13	1318 *i* 1277 *s*	Struck on 8″ plate 40″·5 from left edge, grazing a Palliser bolt which was not moved. Actual indent and buckle 8″·51 over 40″. The upper and lower plates separated 0″·85 over the hole, and 1″ on left edge of target. Part of plate in front of shot driven into wood backing. Back of plate separated 18″ on left side and 13″ on right side of shot hole. The second wood backing driven back 0″·5; inside skin bulged in rear of point of impact.

* *l*, Length. † *d*, Diameter.
‡ *i*, Initial velocity. § *s*, Striking velocity.

Table of Effects.—Continued.

No. of round.	Photographic No.	Nature of gun.	Projectile. Nature and weight.	Projectile. Length and diameter.	Charge.	Elevation.	Range.	Effects. Depth of indent.	Effects. Diameter of indent.	Velocities.	Remarks.
			Elongated steel shot. lbs. 221·5	in. 13·44 *l* 9·15 *d*	lbs. 44	′ 15	yds 200	in. 4·35	in. ...	ft. 1501 *i* 1451 *s*	Struck on 9″ plate between two ribs, 40″ from right edge and 16″ from bottom of plate; ordinary bolt, one inch from shot hole, uninjured; shot remained in plate; base projecting about 7″·5. Plate bulged 0″·1, buckle 0″·5 in 40″. The iron knee sprung.
4	1043	10″·5	〃 299·5	14·05 *l* 10·43 *d*	45	22	200	8	12·75	1324 *i* 1283 *s*	Struck on 9″ plate between two ribs, 36″ from right edge, and grazed lower plate. Indent on lower plate 2″. Actual indent on upper plate 8″, and joining indent made by No. 1042. Clean hole punched in plate. Buckle 0″·27 over 40″. Struck on ordinary bolt which is driven in 4″·5. Separation between two plates 1″·5; wood behind angle iron driven back 0″·75; bulge over 6′ 6″.
5	1044	〃	〃 299·5	14·05 *l* 10·43 *d*	60	14	200	6·1	...	1473 *i* 1425 *s*	Struck on 9″ plate, 96″ from right edge, 29″ from bottom of plate. Centre of shot 5″ from rib. Shot remained in plate; base projecting about 7″·5. Diameter of hole with ripple 12″·75.
6	1045	10″	〃 282	14·46 *l* 9·92 *d*	55	14	200	...	...	1441 *i* 1400 *s*	Struck on 8″ plate between two ribs, 88″ from right edge and 9″·5 from top of plate. Shot remained in plate; base projecting 6″·5. Top of plate bulged. Buckle 1″·85 over 40″. Shot cracked in two; backing forced out 0″·25; one wood bolt broken; five ditto driven in; two armour bolts driven in; three rivets broken.
7	1046	9″·22	Chilled shot 225	16 *l* 9·02 *d*	50	12	200	18·4	...	...	Struck on right side of hole previously made by No. 1041. Depth of hole now increased to 18″·4; second rib from left bulged 1″·25; skin slightly bulged; wood moved back from rib 1″·25.
8	1141	13″	Steel shot. 573	17 *l* 12·94 *d*	100	55	700	...	15	1412 *i* 1268 *s*	Struck on 8″ plate fair on a rib, 99″ from right edge and 21″ from bottom of plate, shot remaining in target; base of shot 4″ from external surface of plate; crack on plate 13″ long, running from No. 1045 and at about 3″ over shot hole. Inner skin slightly bulged; fourth rib from left bulged 0″·5, fifth rib 0″·75 and cracked through; four rivets broken; angle-iron next to plating cracked.
9	1142	〃	〃 574	17 *l* 12·94 *d*	100	55	700	...	...	1420 *i* 1276 *s*	Struck bottom of 8″ plate between two ribs, 84″ from right edge and 12″ from bottom of plate; width of hole at bottom 24″. Small through crack in plate about 18″ to right of shot hole; sixth and seventh rib from left slightly bulged; angle iron cracked on a rivet; one rivet in beam arm broken; shot much set up and cracked at head.
10	1143	〃	Chilled shot 577	21·2 *l* 12·95 *d*	100	50	700	...	20	1430 *i* 1310 *s*	Struck top of 9″ plate on a rib, 99″ from right edge. Diameter of hole at top 20″; depth from top of plate 10″. This shot ploughed through all the backing to a depth of 42″; large semicircular crack round left edge of hole and 12″ from it; shot broke up.

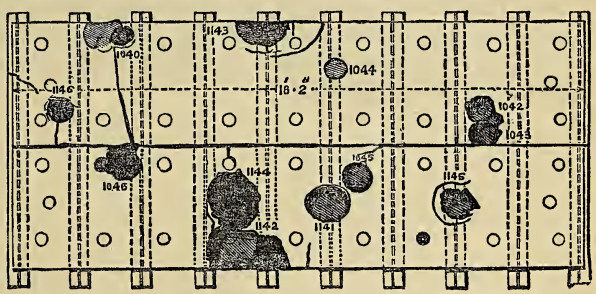
Table of Effects.—Continued.

No. of round.	Photographic No.	Nature of gun.	Projectile. Nature and weight.	Projectile. Length and diameter.	Charge.	Elevation.	Range.	Effects. Depth of indent.	Effects. Diameter of indent.	Velocities.	Remarks.
				in.	lbs.	′	yds	in.	in.	ft.	
11	1144	13″	Chilled shot lbs. 577	21·2 *l* 12·95 *d*	100	50	700	18	...	Pene-trated.	Struck 8″ plate just above No. 1142, and penetrated top of shot hole 12″ from top of plate. Plate cracked on a bolt and opened 1″·5; bolt (Palliser's) pulled through from plate 1″·3, but otherwise uninjured. Plate cracked from No. 1046 to bottom of plate; a new crack above No. 1045, extending to top of plate, which was driven back 1″. The sixth frame from left drawn up from scantling and broken. Inside skin opened over a length of 48″, showing splinters of wood; fifth and eighth ribs considerably bulged and angle iron broken. Shot struck at the joint of the plating and forced in the whole of the plating in the neighbourhood of the joint; thirty rivets broken; shot broke up into innumerable splinters, which would have been very destructive between decks. This shot skimmed the ground before striking.
12	1145	〃	〃 580·5	21·2 *l* 12·95 *d*	100	50	700	22	19	...	Struck 8″ plate fair, 4′ from left edge, 1′ 4″ from bottom. Diameter of hole 1′ 7″ horizontally, and 1′ 4″ vertically; crack round top of shot hole, and vertical crack from top of plate 9″ long; buckle 1″·3 over 6′. Shot grazed 79 yards short before striking; shot broke up in hole; when the fragments were removed the depth of indent measured 1′ 10″; one through armour plate bolt (not Palliser's) broken. *Note.* From the appearance of some of the pieces of the shot it seems to have been cracked in the chilling. *Rear.* Slight bulge in third rib; one nut broken; one angle iron cracked at a rivet.
13	1146	〃	Steel shell 567·5	19·5 *l* 12·94 *d*	100	1° 2′	700	3·5	...	1427 *i* 1307 *s*	Struck 9″ plate, 2′ from right edge and 1′ 6″ from bottom of plate. Plate cracked through from centre of indent to right edge and bottom of plate. A large crack running from No. 1040 down to bottom of plate; shell broke up. Buckle of plate horizontally 2″·2 over 6′ below indent and 1″·5 above. *Rear.* Slight crack in the angle iron of the beam knee and outer angle iron of an iron frame. No. 1044 was knocked out by the concussion, and the indent found to be 6″·1 deep. Shell after firing, length 15″·3, breadth at head 14″·55; broken longitudinally.

Remarks.

On the completion of the trial of the 21st June, the target was dismantled by order of the Admiralty, with a view to ascertain with greater exactness the actual damage sustained by the structure.

It will be observed by referring to the annexed drawing, that the greatest effect was produced by rounds Nos. 1041 and 1046, which struck nearly on the same spot, but the damage in this instance is limited to the penetration of the 8″ armour plate, and about 9″ of the wood backing, the two $3\frac{1}{4}$″ plates and the ribs immediately behind the point of impact are slightly bulged, but in other respects are uninjured, and the structure may be said on the whole to have sustained no material damage.



The actual effect produced by the 13″ gun or (600-pr.) with which the experiments were resumed on the 7th December, can only be determined by examination when the target is again taken to pieces; a course which the Committee understand the Admiralty intend to pursue. A reference, however, to the Table of Effects will show the observed results of each round in detail.

It will be seen that in no instance was the target penetrated when struck on a sound place, the only shot which did penetrate (round No. 1144) struck within 18 in. of the hole made by a previous round (No. 1142), where the iron must have been considerably weakened behind, by the tendency of every blow to break off a disc of metal, which is two or three times the diameter of the shot, on the reverse side of the plate, and would consequently have extended to the spot struck by No. 1144: the protecting armour plate was 8 in. thick in this place.

It did not appear to the Committee that the plates were of first-rate quality; the welding seemed to be imperfect; they did not, however, crack to any great extent, taking into account the nature of the blows delivered on them.

Opinion.

The Committee, having carefully considered the above results, are of opinion—

(1) That a structure such as is represented by the "Hercules" target appears to be practically impenetrable by the heaviest known ordnance, so long as it is in a sound state; and it appears to them to be a question well worth the consideration of the Lords of the Admiralty, whether it may not be advisable to reduce the power of defence in the "Hercules" by substituting 8″ iron plates for the 9″ now proposed, and increasing her power

of offence by adding the weight which would thus be economized to that of her proposed armament.

(2) That steel shells of the Armstrong form are valueless as shells when fired against such a structure.

(3) That chilled iron at £20 per ton appears to be as good a material for armour-piercing shot as steel at £80 per ton, at least in the form of projectiles used in this experiment.

(4) That the employment of armour-plate bolts, of large sectional area, has proved entirely successful. Of the two descriptions under trial, viz. those of ordinary form and those on Major Palliser's design, the latter have maintained their superiority.

(Signed) J. H. LEFROY,

Brigadier-General, R.A.

President.

METHOD

OF

OBTAINING THE PICTURE OF A GUN IN THE ACT OF FIRING,

AS PROPOSED BY Mr M'KINLAY, PROOF-MASTER.

Office of Inspector of Ordnance,
Royal Arsenal, Woolwich,
15th January, 1866.

Sir,

In the early part of last year my attention having been drawn to an attempt which had been made by the Photographic Establishment of the Arsenal, to procure a picture of a gun used by the Gun Cotton Committee, at the instant of discharge, but which failed in consequence of the act of opening and closing the camera being dependent upon the manipulation of the operator, it occurred to me that the object could only be satisfactorily obtained by making this opening and closing subservient to the actual firing of the gun; that is, connecting therewith, the method used for discharging guns at proof by means of galvanic action.

Mr M'Kinlay, the Proof Master of this department (who is well known to many officers as being connected for some time with our Institution, previous to the termination of his service in the Royal Artillery, and later, as the inventor of the galvanic tube), with whom I conferred on this subject, has produced an apparatus which has, with the kind assistance of Mr Abel and his assistants in the Photographic Establishment, answered beyond our expectation; and as it is a matter in which many officers will take an interest, and may be applied to many useful purposes in our profession, and when more elaborated may lead to important discoveries and results in the science of artillery, Mr M'Kinlay has been good enough at my request to furnish me with a paper describing his adaptation of photography to this novel purpose, and some further application which he proposes in reference to experiments in gunnery, for communication to the members of the Institution.

I have the honor to be,
Sir,
Your obedient servant,
R. K. FREETH,
Lieut.-Colonel, R.A.,
Inspector of Ordnance.

The Secretary,
Royal Artillery Institution,
Woolwich.

Among the many applications of photography to the different branches of science, since its first introduction, my attention has been called to one of a novel description—viz.: to take the picture of a gun in the act of firing. This may appear an easy matter with any of the instantaneous processes in constant use, but the difficulty of opening and shutting the camera at the precise instant of time, is an operation too nice to be done by hand, inasmuch that the gun, on the instant of discharge, is set in motion; and a picture taken under such circumstances would be anything but satisfactory.

Having designed an appliance to an ordinary binocular camera, I have succeeded perfectly in taking pictures of a gun at the time of discharge—the flash, smoke, and projectile are seen at the muzzle of the gun, which is clear and well defined in all its details, showing that the recoil had not then commenced; the tube by which the gun is fired is also seen making its escape from the vent in a state of ignition.

To give the reader a general idea of the apparatus and its mode of action, it is necessary to say that a galvanic tube is employed, such as is used in proving ordnance.* As this tube performs an important part in the present arrangement, it may be briefly stated, that the same galvanic current which fuses a small platinum wire in it, and by which the gun is discharged, is also used, at the same time, to open and shut the camera by the employment of electro magnets.

The camera which has been used in the experiments is a double one, capable of taking two views, and, by the arrangement, at different instants of time; a revolving disc moved by a spiral spring is placed in front of the lenses; in one position of the disc the camera is opened, and in another it is closed.

When the gun is ready for firing the disc is wound up, and kept in its place by means of a catch controlled by an electro-magnet (connected with the gun by wires from the galvanic battery); on the instant of communication being made the electro-magnet removes the catch, the disc rotates and opens the camera, and in this state it remains until the gun is fired; the current is then broken, and instantly the camera closes.

The arrangement for keeping the camera open until the gun fires is very important, as there is sometimes a pause between contact being made with the battery and the discharge of the gun, in consequence of the galvanic power varying, and sometimes the tubes are not equally sensitive; in either case it would lead to a failure; this movement is the most important, but most difficult in the arrangement.

It will readily appear that the same current being used to fire the gun and to open and close the camera, ensures such simultaniety of action as is unattainable by any of the ordinary means hitherto employed.

By a slight modification of the apparatus, the flight of projectiles may be taken at any given part of the range; also the appearance of iron plates, or the targets, at the instant of impact of shot or shell.

P. M'KINLAY,
Proof-Master.

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* Vide Vol. I. p. 362.

General view

Fig 1

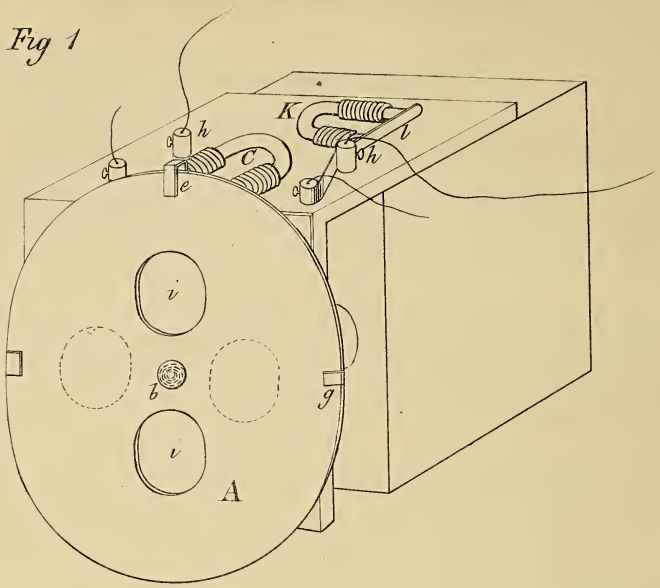
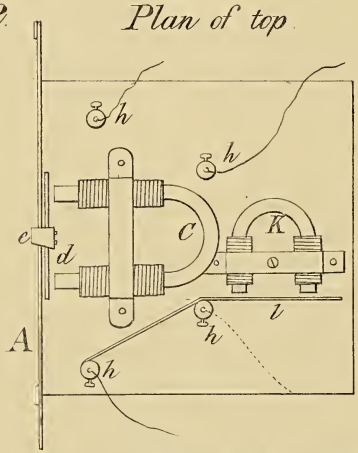


Fig 2. Plan of top



Liberator & catch
full size

Fig 4.

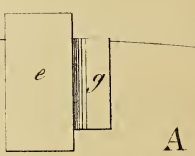
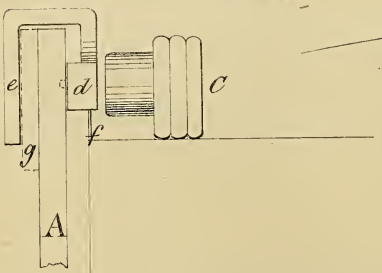


Fig 3.



Lithographed at the Royal Artillery Institution

Description of Drawings.

Fig. 1 is a general view of camera and apparatus attached, the same letters have reference to the same parts in each of the figures:—

A, rotating disc, shewn as set before taking a photograph, with the solid part opposite the lenses indicated by dotted lines; *b*, the spiral spring wound up; *e*, the catch on armature, and pin set to prevent rotation (see Fig. 3); *c*, an electro-magnet; *d*, armature of magnet, on which is placed the catch *e*, and pin for liberating the disc; *f*, a flexible spring to support the armature, &c.; *g*, a plate of brass to act as a stop when in contact with the catch *e*, in which position the holes *ii* are opposite the lenses, and the camera open; *hh*, are binding screws in connection with the magnet, to which the wires from the galvanic battery to the gun are attached, forming an unbroken communication with the magnet in the circuit.

When the gun is to be fired, and photograph taken, communication is made with the galvanic battery; at that instant *c* is magnetized and attracts *d* towards it, withdrawing the pin, and bringing the catch *e* close to the disc; rotation commences, and continues until the stop *g* abuts against the catch *e*, where it is held, and thus the camera is open for an instant of time until contact is broken by the discharge of the gun; *c* is then demagnetized, the armature and catch return to their original position, *g* passes under the catch (see Fig 3), rotation is completed, and the camera closed.

To adapt this arrangement to photograph projectiles in flight, a second electro-magnet *K*, is used (Fig. 2) with a spring armature of thin iron *l*, which presses on the binding screw *h*, and completes the circuit of the magnet *C*, when *K* is not in action, but when so, it attracts the armature from the binding screw *h*, cutting off the current from *C*; it will thus appear that the magnetization of one magnet follows the demagnetization of the other, the spring *l* acting in two capacities, as a conductor in conveying the current by the binding screw *h* to magnet *C*, and as an armature to magnet *K*, thus controlling the action of the former.

To take a projectile in flight it is necessary that a wire screen be used (similar to that in experiments with the Navez instrument), the wires in connection with the galvanic battery having magnet *K* in circuit, and armature *l* in contact, consequently not touching the binding screw *h*; when the wire screen is broken by shot passing through it, *K* is demagnetized, *l* returns to *h* and completes the circuit with *C*, the disc *A* is set in motion as before described, showing the trajectory of the shot during the time the camera was open, this time being determined may approximately measure the time of flight.

To take impact of projectiles the same arrangement is used, the wire screen being placed in front of object to be fired at, and at such distance that the camera may be fully open at that instant of time.

The two latter uses have not been practically tested in consequence of this season of the year being unfavourable for instantaneous photographs, but it may fairly be assumed that the arrangement that can take a shot in its highest velocity is also capable of doing so when much reduced.

MY JOURNAL DURING THE BHOOTAN CAMPAIGN, 1864-5.

BY CAPTAIN F. G. E. WARREN, R.A.

Of the kingdom of Bhootan we know next to nothing—a beautiful shadow of doubt covers all connected with it. Its government is a joint-stock business, the head of the firm being the strongest man in the country at the time being; we know the names of certain functionaries, though what their functions are we can only guess at. The religion is Buddhism, with a servile devotion to dirt.

Bhootan is about 250 miles in length, east to west, and 90 miles in breadth, north to south; of this a long stretch varying from 20 to 25 miles in breadth and the entire length of the country lies in the plains, the remainder in the mountains of the Himalayas; thus the country boasts every degree of climate, the overbearing heat of Assam, the bracing air of England, and the cold of Greenland.

Our earliest connection with the country was in the beginning of this century, and since then all our correspondence with it has had reference to outrages committed by the inhabitants of Bhootan on British territory and subjects.

The long stretch of plain country before mentioned is divided into eighteen districts, called dooars, from the word Dooar *anglicè* Gate, and are named after the mountain passes or gates which lead into the hills. Most of the dooars were wrested by the Bhooteas from the Assamese previous to our occupation of Assam, while other dooars had been held by Bhootan for a considerable time. On our occupation of Assam we found that Bhootan had been receiving rent for certain of these lands, and this payment we continued.

Robberies, murders, cattle-lifting, and violence of every description followed one another in rapid succession—Bhootan the aggressor, England the sufferer. In 1828, 1834, and 1836 we find we remonstrated in vain, down from the hills came the gangs of robbers, and the wretched inhabitants of our frontier led an unenviable time of it indeed.

In 1838 Captain Pemberton was deputed to go to Poonakh, the capital of Bhootan, to make some satisfactory settlement regarding these outrages. He went by the eastern road, *viâ* Gowhatty and Dewangiri, and found the country in the throes of revolution; the Paro Penlow held the west, the Tongso Penlow the east country, the nominal ruler, the Dhurm Raja, being nowhere. This happy prince is (like the Chinese Emperor) supposed to be something god-like; he is called an incarnation, and is in reality a puppet. The method of choosing his sanctity is sweetly simple and innocent. The shoes and drinking cup of the late departed Dhurm Raja are placed among

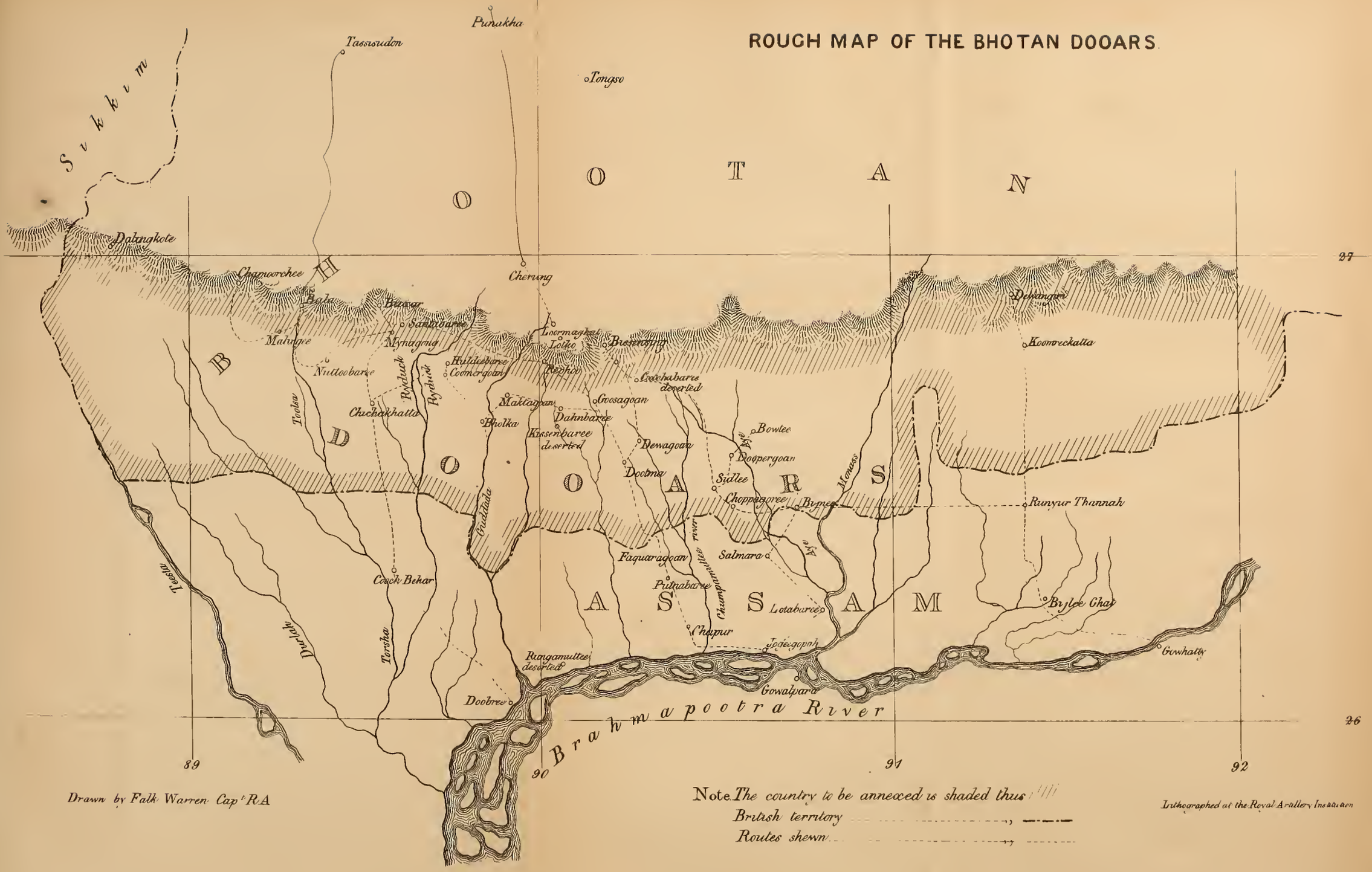
HE BHOTAN DOOARS.

Drawn by

shaded thus //////

Lithographed at the Royal Artillery Institution

ROUGH MAP OF THE BHOTAN DOOARS



Drawn by Falk Warren Capt RA

Note. The country to be annexed is shaded thus ////

British territory ----------, ———

Routes shewn ----------, ----------

Lithographed at the Royal Artillery Institution

numbers of others, and the chosen successor (a child of tender years) will point out those of the late Simon Pure; then follow rejoicings and drunkenness *ad libitum*.

Captain Pemberton could do nothing. In 1839 we have more outrages. In 1841, in retaliation, we attach three Assam dooars; in 1843 we agree to pay Bhootan a revenue for these of £1000 a year, besides £500 for another district, thus actually paying the ravager for his crimes.

In 1855 two Bhootan princes arrived in our territory, claiming an increase to this black mail, and on its being refused they on their return journey home plundered British subjects to the value of £286, torturing men to disclose their treasures. We demanded the culprits and restitution; both were denied, but we stopped the money from the next year's revenue, and were content. Thereupon the Tongso Penlow addressed a threatening letter to the British authorities, backing it up by outrages and robbery. We remonstrated again, using the now tiresome threat of occupying the dooars, and saying that should they apologize for their naughty conduct we would raise the black-mail by £200 per annum more. The answer to this was three further outrages and the murder of a British subject, just to vary the monotony of the thing.

The Bengal government seeing some extenuating circumstances, resolved "not to proceed at once to coercion," and the consequence was that in the next four years there were recorded 33 more cases of outrage, 45 British subjects being carried off into captivity, and in one single case over £2000 of property being plundered.

In 1861 the Bengal government decided to do something. One of the dooars was occupied, and the Bhootan authorities were informed that this district would be held until the captives were restored and the guilty parties punished. On this occasion the Governor-General's agent, Colonel Jenkins, acted with too much decision, for he threatened Bhootan with further annexation in case of their refusing the British demands. On the Bengal government pointing out his error to him Colonel Jenkins expressed his regret and was forgiven.

Still the outrages continued, not single exceptional cases, but in different districts, and in 1862 the Bengal government decided to send a mission to Bhootan. This mission left in the spring of 1864, and the Papers on Bhootan, presented to the House of Commons in 1865, furnishes the following particulars:—

"Mr Eden seems never to have officially reported to the government of India his departure or progress. The letter of 21st April, received here on 5th May, appears to be the first official report of any kind laid before government. It communicates to government the entire failure of the mission. After pressing into the country in spite of as plain warnings as any native government ever gives that the mission was unacceptable, and in spite of insolent treatment on the way, the envoy reached Poonakha on the 13th of March, where he found the Deb and Dhurm Rajahs were puppets in the hands of the Tongso Pillo, the successful head of the late insurrection, and the very man who had been most injured by the annexation of the Assam dooars. By this man, who refused to treat except on condition of the restoration of the Assam dooars, the mission were subjected to unheard of treachery and insults, were derided, buffeted, spat upon, and

threatened with imprisonment and the stocks. With difficulty the mission obtained permission to return after the envoy and Cheeboo Lama had signed an agreement in duplicate that the British government would re-adjust the whole boundary between the two countries, restore the Assam dooars, deliver up all runaway slaves and political offenders who had taken refuge in British territory, and consent to be punished by the Bhootan and Cooch Behar governments, acting together, if they ever made encroachments on Bhootan. The envoy resolved to sign this document after considering in concert with the other officers of the mission and rejecting the only other courses which appeared open to him, viz. first, that he and Cheeboo Lama should remain as hostages on condition of the rest of the camp being permitted to return; and, second, attempting to escape by night. Both copies of the agreement which he signed were marked as signed 'under compulsion.'

"There are three important points on which the envoy appears to have departed from the explicit instructions which were given to him:

"1st, He seems to have pushed on ahead, leaving the presents* to be brought up afterwards, whereas he was told to open his negotiations by delivering the presents.

"2nd, He commenced his negotiations by delivering to the Durbar a copy of the draft treaty, thereby showing his whole hand, although several of the clauses were alternative, and some of them he was required not to press if they interfered with the political objects to be obtained. It is remarkable that the only clauses to which formal objection was made, however insincere and treacherous the Durbar may have been, were those articles (8 and 9) on which government entertained doubts, and one of which the envoy was instructed not to press.

"3rd, Although the envoy marked the documents as signed under compulsion, he gave the Durbar no reason to believe that he had done so; on the contrary, the papers appear to have been signed with all the formalities of a voluntary engagement, and the envoy accepted presents for the Governor-General. All this was a deliberate violation of the last paragraph of the instructions of 25th September, 1863.

"The envoy asks instructions as to the disposal of the presents, consisting of three ponies and some pieces of silk, whether they are to be sold or returned through the Dalimkote Soubah; he also seems to have received a letter to the Governor-General, which he has not yet submitted."

The consequence of the treatment of this mission by the Bhooteas, was the war in 1864-65, when the government decided to attack the dooars or level country of Bhootan.

The two Penlows before mentioned have full power of life and death, and for the government of their respective countries they have under them officers styled Soubahs and Jungpeus; but these men's power is most

* He has not furnished the list of these presents, which he was told to submit.

unstable, a new aspirant to the honour has but to bribe the Penlow and he is allowed to try his hand at ousting him who holds the appointment; a fight takes place, and the victor is allowed to hold authority on the payment of a few more bribes. The people do not appear unhappy, neither do they seem to be tyrannized over—at least I speak of the native Bhootea; the Bengalee slave, however, leads a miserable existence, his very nature being unable to bear against the cold climate of the mountains.

The monasteries taking away as they do so many of the able-bodied men, leave a large proportion of unmarried women, and the existence of polyandry makes the disproportion between married men and women still greater; hence vice and immorality reign throughout the country, and the natural consequence, disease, commits fearful ravages among the people. An intelligent Bhootea of the superior class told us that there were few men or women in Bhootan who had not suffered from the terrible scourge.

I cannot but believe that this is the main cause of so few Bhooteas reaching an advanced age, for the climate is pre-eminently good. Small-pox also prevails to an alarming extent, nearly every full-grown man is marked by it; their dirt, vice, and gluttony lays them open to all diseases. They are besides inveterate drunkards, never losing an opportunity that presents itself of becoming intoxicated off a vile spirit made from millet, the taste and smell of which is equally sickening.

The Bhootea is armed with bow and arrows; he has besides a straight, heavy sword, without a hilt, which he uses for all purposes, for felling timber and carpentering as well as for fighting. The Sepoy has a matchlock and helmet, the latter made of iron or brass, with a flap of chain-armour hanging down the back. The arrows are often poisoned, but not one of our men wounded with a poisoned arrow died from the effects of the poison, so it may be safely considered harmless. The catapult is extensively used in their forts, and is a formidable weapon of defence, the steep sides of the hill presenting every advantage to a falling mass of stones, which reach into steep gullies not visible to a matchlock man. The Bhootea is an admirable woodman, and few surpass him in rapidity and dexterity when building stockades. In appearance he is fairer than the inhabitants of Hindostan, of decided Tartar physiognomy, stoutly built, and with little or no hair upon his face. His dress consists of one garment, only a long wide dressing-gown, fastened by a sash or piece of cotton round the waist; in the breast of this coat he carries all the articles he requires for his toilet, and also his wooden drinking cup, without which he never moves.

This dressing gown is, when new, of brightly coloured cloth, often in stripes, which gives a gay appearance to the picturesque savage, armed, as he always is, with sword, bow and arrows, but as it is never washed, these colours soon become indistinct.

Early in October, 1864, I received orders to proceed to the eastern frontier of India, to join the force then assembling for the invasion of Bhootan. After making all arrangements incident to a journey over 1000 miles, I proceeded towards Calcutta, for I found it impossible to obtain the slightest reliable information as to the most direct route to the place mentioned as my destination, Cherrapoonjie.

On arriving at Calcutta I discovered that this most direct route was by steamer, up the Brahmapootra; and I was further informed that the corps

I was about to join had left Cherrapoonjie, and that my best plan was to proceed to Assam. Two of the bases of operation, Goolpara and Gowhatty, being in that country and on the Brahmapootra.

Having received orders to proceed to Assam, by the steamer "Koladyne," I embarked with several other officers similarly bound, the steamer having two other craft filled with stores and ammunition, for the necessities of the campaign.

The vessels used on the Ganges and Brahmapootra must be of low draught, and hence it is necessary that the cargo should be carried in boats, called flats, as the machinery and coal are found to sink the steamer itself to the fullest maximum draught of five feet. These flats are fastened on either side of the steamer, and by this means we were enabled to pass over the numerous sand banks that render the navigation of these great rivers so dangerous, and besides to carry a very large cargo. When moving troops along points accessible from the river, they can be carried on board these flats, two decks being built for such a contingency. In the present case we had on board a company of native sappers and miners, under Lieutenant Urquhart, and some 200 coolies, intended for the carrying of the future sick and wounded.

It was subsequently discovered by the passengers, that they might have been saved the inconvenience and expense of ten days' voyage in the steamer, as at the lapse of that time we came to a town on the Ganges, called Koostia, where the Eastern Bengal Railway has its terminus. This place is reached in four hours by rail from Calcutta, whereas, we had taken ten days by water, having had to pass through the elaborate winding passages of the Sunderbunds, the delta of the mighty rivers, Ganges and Brahmapootra, a stretch of country, well known for its deadly climate.

A few more days saw us on the waters of the Brahmapootra, which we had entered by a connecting and natural channel from the Ganges; but the scenery presented the same monotonous continuance of low sand banks and paddy fields; and it was not until we approached Assam that the dead level of the horizon was broken by the rising up of the Garrow hills on the left bank.

The days had been hot and the clouds of sand blown from the banks, whenever the wind arose, had made our journey a rather trying one. At night musquitoes would occasionally attack us savagely, should we have stopped in the neighbourhood of their haunts: for so intricate and dangerous is the course of this river to ships, that it is necessary to anchor at sunset every night. If near the bank, the native soldiers were permitted to land and cook their dinner, their creed forbidding the cooking of food on board ship; they are thus obliged to subsist upon parched grain during the voyage. The frugality and abstemiousness of the native soldier makes him doubly valuable in a campaign of the nature we were about to enter upon, as the commissariat arrangement for his diet and comfort are far more simple than those necessary for British soldiers.

The passengers consisted, as I before mentioned, of officers, bound to join the Bhootan expedition, and among them was a Captain Austin, one of the mission under the Hon. Ashley Eden, who had gone to the Bhootan capital of Poonakha the previous year, and whose ill-treatment had brought about this the latest of England's little wars.

It had been decided that Bhootan should be entered at four points. The two on the right formed the right brigade, under Major-General Mulcaster; those on the left formed the left brigade, under Brigadier Dunsford. Taking from the right, they were to move upon Dewangiri, Bessin Singh, Buxa and Darlingkote respectively, points about 40 miles apart *as the crow flies*, but an indefinite distance apart when the totally unknown nature of the country came to be considered.

As no roads existed, all the carriage of the different columns had to be effected by means of elephants, or coolies; but the supply of these fell far short of the requirements, and hence the forces under the junior officers suffered under considerable difficulties. The small number of coolies it was found possible to collect, and their continual escape from the work imposed, rendered them a useless dependency. Had arrangements been previously made for having them enrolled and placed under proper officers (as was done later when the war had virtually ended), then these coolies would have proved a valuable assistance to the force.

Considering the high pay given to these men and the considerate way in which they were treated—for I never once witnessed or heard a single case of their ill-treatment—it is difficult to account for their aversion to the work, unless as was generally said, they believed that we were marching to certain destruction, so high an opinion had they of the power of our enemies.

Another method for carrying supplies which was greatly depended upon, was by bullocks, droves of which were sent from districts in our own territory; but as some forty bullocks would be under one or two men, the others having deserted, and as these animals turned deaf ears to the alluring language of men not accustomed to them, they had at last to be almost abandoned. The commissariat officers would strive desperately to use them, and did so at first with some success; but the nature of the country, which allowed them to stray, and the rank nature of the grass on which they had to feed, soon reduced them in numbers and condition, and their carcasses were left at our camping grounds, marking but too plainly the line of our march. The drivers of these bullocks, like the coolies, evinced the greatest repugnance to the campaign, so different from the general feeling of camp-followers, who know that when following an army they have every chance of pillaging to their hearts' content, and accumulating a fortune.

The right centre column, that to which I had been appointed (for the purpose of commanding the artillery details), assembled on the right bank of the Brahmapootra, opposite to, and five miles below the town of Gowalpara, at a village called Jogeegopah, or the "Cave of the hermit." The tall rank grass was cleared and we were soon shaking ourselves down to that degree of acquaintance so essential to the enjoyment of a campaign. Our little force consisted of a wing of the 12th Regiment Native Infantry, and a wing of the 44th Regiment Native Infantry, 50 Sappers, natives also, with two guns and two rocket apparati, altogether about 700 men, under the command of Colonel Richardson, of the 44th Regiment Native Infantry, a gallant officer who had distinguished himself greatly by the bold, decided, and rapid manner in which he had broken any power of the Cossiahs that dared to assemble on what he called his dunghill in the Jynteah and Cossiah hills; he successfully attacked and took every stockade that was there built, and was the first in at every one, and he had active men to emulate him in his

hardy Ghoorkas of the 44th. At last a Cossiah bullet broke his shins and quieted his ardour, or rather his pace. This Cossiah campaign was one of England's little wars of which nothing is known at home, but in which there was much silent endurance and untold privation.

The 12th Regiment consisted of men of different classes; the old Sepoy, tall, straight, and spindle-shanked; and the more warlike though less cleanly Patan and Sikh. The men were dressed in red, with red turban, a telling uniform for parade but one scarcely adapted for the concealment necessary in hill and bush fighting. The 44th Regiment, principally hill men from Nepal, called Ghoorkas, were dressed in dark-green, and though badly armed (having the old heavy brown bess) they had the look of men meant for hard service; they were fresh from the Cossiah campaign, the best school in which a soldier could be taught stockade making and taking, and how to march well with little to eat and less to wear.

The climate at our rendezvous in Assam in October was cool and pleasant; the dews at night were the heaviest I have ever known, but the force remained healthy. Game abounded in the neighbourhood—buffalo, pig, and deer were killed in considerable numbers; as also smaller game, such as partridge, bustard, and wild-fowl. Tiger and bear, and also rhinoceros were known to abound, but the jungle grass was so high and dense at this season of the year that they could not be seen, though often within a few yards of the excited and expectant sportsman. The wild buffalo is identical with the tame, owing to the villagers never keeping tame bulls, but trusting to the wild ones for their offices; several tame cow-buffaloes fell victims in consequence, but as the owners got well rewarded, I rather believe that they assisted in more than prevented the deaths.

The commissariat arrangements for an advance could not be completed, in consequence of the carriage necessary for baggage and provision having been taken by other officers of different columns. However, at length Colonel Richardson determined to go on as best he could, and accordingly moved off with one half (or right leg) of his force to Bijnee, the nearest point in Bhootan territory (where a detachment of our force had been early sent), returning the baggage animals to bring up the other half (or left leg).

Two mornings after Colonel Richardson had left, several elephants arrived in camp, and I was desired to follow with the sappers as an escort; a number of bullocks were given me for baggage, as also provisions for three days, and anxious to get to the front, we gladly prepared for our start.

A herd of bullocks was driven towards the lines we occupy, and among terms of endearment and cries of rage the soldiers proceeded to lade the brutes; but alas! no sooner would the gentle bile (*anglicè* bullock) have his load fairly and equitably poised than with a wriggle and a twist he would jump it off his back, and, turning round, stare innocently at the ruin. In one instance, when a well-packed load had been cunningly and securely fastened, the gentle animal performed a series of buck jumps that would have done honour to a "Waler."* Some of these animals when laden would walk demurely away (every man was engaged assisting others when

* Waler, a horse from New South Wales, proverbial for their buck-jumping qualities.

once his own work was done) and penetrate far out of sight into the tangled wilderness of grass that lay outside the lines, and would be found only after a weary search.

When at length some 20 or 30, more tractable than the rest, were collected and driven in the direction they were to go (we could not talk of roads), there was first passive resistance, which gradually grew into livelier rebellion and finally into a furious stampede. There was no marching in that method, as all the little force was engaged in "woo'ing" and loading, in catching cattle and making dashes at one that broke back; so to get away from that place and not be obliged to undergo another such melancholy start we put heavier loads on the elephants we had got, as I knew that stores of meal, &c. (all that was necessary for the rations of native soldiers), were collected at our halting places ahead.

A march of twelve miles brought us to the village of Lotabaree; the road had been distinctly marked out, and we proceeded rapidly. The nullahs we had to cross had been bridged for men and cattle, but the elephants had to ford the deep, muddy streams, and in one instance one of these huge animals took over an hour extricating himself; he had once before been "fixed" in a quagmire and now refused even to attempt to go on, but trumpeted in a crying, feeble manner.

The whole of this first day's march lay through a wide plain, now covered with dense jungle grass high above a rider's head, now spreading out into a short expanse of shorter but equally rank vegetation; twice we passed through villages with a considerable amount of cultivation around, all rice, with its single field of mustard. The houses were entirely built of bamboo, the walls being plaited sheets of that invaluable tree, and the floors raised about one to two feet above the level of the ground, with mats of bamboo matting laid down here and there. The inhabitants are a poor race, without energy—content to live as their fathers did, eating rice and keeping up the mummery of caste.

The civil authorities had collected as many of the able-bodied villagers as they could, as coolies, to carry loads; we had some eighty, but as I before said, so determined were they to get away that they had to be placed under a guard. And now, when we arrived at Lotobarre, it was amusing to see how they cooked, eat, and followed the dictates of nature by word of command. Any more respectable-looking, or as was believed, more trustworthy coolie who was trusted, made his escape, causing the greatest inconvenience, as his load had to be carried by some other method, and we were already heavily laden.

The second march led us through a country similar in general appearance to that of the day before. Passing a small village about half-way, which, with its few acres of surrounding cultivation, looked like an oasis in the midst of the wide plain of luxuriant jungle grass; our path led us close to one of the hills which rise so strangely out of the unbroken surface of the plain; its slopes were covered with an impenetrable tangle of forest trees, interlaced by thorns and creepers, while at its foot lay a ditch of boggy morass surrounding it on all sides. As a fastness for defence it would be difficult to find one more suitable, but man seldom if ever attempts to penetrate here, and the wild elephant, the tiger, bear, and buffalo have it all their own way.

Eight miles brought us to the village of Salmara; again it was necessary to provide the troops with grain from the stores at the place—the tired-out deputy of the commissariat with his helpless horde of bullocks was nowhere; indeed, the followers of this department of the army had to do without rest or food during this part of the campaign, uninterrupted and sleepless vigilance being necessary to keep together and drive on, the herds of bullocks, whose pace was tediously slow and whose propensities were all to straying away and grazing.

At Salmara we lost the services of the only medical officer attached to the 44th Native Infantry, the Artillery, and Sappers. This officer had previously suffered from the sun, and it was now necessary to relieve him from the work and exposure incident to a campaign; this left the whole medical duty to one assistant-surgeon, Dr Caird, and as the force was divided, there was one portion without any medical assistance whatever, but the matter weighed lightly on us, as all our healths were excellent, and the prospect of active service left little thought of anxiety on our minds.

The only provisions we found it possible to purchase at these villages in Assam were fowls, and these were sold exceedingly cheap. The people presented a contented appearance, and their houses were well built and snugly enclosed by palings of split bamboo.

From Salmara we had a march of twelve miles to Bijnee, over the same kind of country as before; the old bed of the river Aye had about 2½ feet of sluggish running water in it—the elephants forded, the men crossed on rafts which had previously been prepared for the purpose. The new bed of the Aye, two miles further on, was filled by a rapid clear stream of water, six feet deep, the passage of which detained us somewhat.

On approaching Bijnee we caught sight of the tents of the 44th, and after crossing another stream, joined the advanced force, and for the first time had our camp in Bhootan territory.

Bijnee—on a tributary of the Monass which runs three miles to the east—is a town of about one hundred houses, and boasts an old fort; it is owned by a Ranee, who possesses land on both sides of the boundary line. All the inhabitants who can, build an upper storey to their homesteads, in which they live above the wet and miasma of the rainy season. Wild animals of the larger kind, such as elephants, rhinoceros, buffalo, and tiger abound in the swamps around, their tracks are over the whole country; we heard tigers growl repeatedly, and saw several herds of buffalo, but unfortunately at the season of the year we were there the jungle was too dense and high for success in sport; Captain Shuldam, however, killed two buffalo here.

It may be as well to mention how the guns and ammunition of the artillery were carried. The two guns (12-pr. howitzers) of 3 cwt. were slung on either side of an elephant, on whose back was placed a cradle made for the purpose; the gun carriages were packed on another elephant, and the two-pair wheels slung on either side of the same animal. The ammunition —100 rounds per gun, together with the box of implements—went upon five other elephants, packed in the common small magazine boxes, which hold eight rounds in each, forming loads too cumbrous and heavy for carriage by mules, coolies, or by any ordinary method when travelling difficult mountain paths; one other elephant carried the forge, materials, and tools, the supply of which was of the scantiest kind. The elephants

chosen for artillery purposes are the best that can be procured, and of those attached to us in this instance three were "koonkees," as those are named which are employed for catching their wild brethren. The two rocket-stands, rockets, and sticks were carried on another elephant.

The men employed as gunners were the company of Eurasion, or Native Christian Artillery, commonly called half-castes; they were rationed and clothed the same as English troops, a matter to be regretted in a campaign, in consequence of the great extra trouble it caused the commissariat in having to supply fresh meat, rum, and vegetables; but Captain Cordner, who commanded this company of artillery during the Cossiah and Jynteah campaign, assured me that the better feeding greatly increased the strength and endurance of the men; I must say, that the ease with which they completed long and wearisome marches over sticky, bad ground, often wading knee deep in water, with a burning sun overhead, reflected great credit upon them; their small size and delicate frame, however, was not quite up to the heavy and laborious task of mounting and dismounting the ordnance and heavy gun-carriages when coming into action, or packing up when ceasing fire.

The objection to the 12-pr. howitzer employed was that it could not be carried, either on a mule, or by two men when slung on handspikes, and taken by a narrow mountain path; but the greater weight of metal gave the gun far greater precision of fire and range. These guns were, I believe, identically the same as what are employed in boat service in the royal navy, and not Armstrong guns, as is everywhere reported when speaking of those of the other half-battery which were lost in the disaster at Dewangiri, and which were attached to the force called the right column. These guns were never intended by any artillery authority to be used purely for mountain service, neither were the arrangements for the carriage of ammunition and stores equal to such a service; indeed, in the simple and very necessary requirement of rope, there was at first a lamentable deficiency, and materials for repairs there were none.

The following days the remainder of the force, consisting of the 12th Khilat-i-Ghizie regiment, under Colonel Stevens, arrived at Bijnee, and the general orders for the guidance of the columns about to enter Bhootan were promulgated. Amongst other regulations every man, of whatever creed he might be, was obliged to take quinine daily, as the low, marshy, uncultivated country we were about to pass through bore the worst of characters, and by competent judges was named pestilential in the best of seasons, and deadly in the rains.

In the absence of medical men to the different corps some officers had to attend, and, indeed, personally weigh out and deliver the dozes of quinine. It was laughable to see the distortions of face as the obnoxious draught went down, but the peremptory orders of the Commander-in-Chief prevented any objections on the score of creed, as is too often allowed in the army of India. After a time the men grew to like the medicine, and I have seen the same who would at first spit the flavour away, actually grumble at the smallness of the dozes a week afterwards. I ought to mention that the use of arsenic as a cure and preventative for fever was also recommended: a medical record of the respective qualities of these medicines would be interesting and useful.

The commanding officer, Colonel Richardson, pushed on from Bijnee with a small escort as far as Sidlee, the seat of a rajah, some 25 miles to the north-west of us. He found the road (we will call a winding track by that name) passable for the force, and we accordingly marched, going on the right and left leg principle as before, the artillery and sappers going with the advanced leg.

The first day's march to Choppagoree proved a tiresome one of 15 to 17 miles—the sun very fierce, and the scantiness of water making it oppressive to the soldier. The country was an open plain covered with grass, sometimes low, and at times rising into a forest of dense jungle. Five miles from Bijnee we had to cross the Aye river again; the ford here would only just allow the elephants to pass laden—the stream was very rapid, the water very cold and beautifully clear. One village of some twenty houses we passed half-way; it boasted a good number of goats, pigeons, and fowls, and had a little rivulet at hand, in which our men slaked their thirst.

We passed at the very foot of a considerable hill, of I should say about 750 to 1000 ft. high; as usual, it rose straight from the unbroken surface of the plain, no undulating waves of land marking where it joined, the natural ditch of shaking bog surrounded it apparently on all sides, and the interlaced forest of trees and creepers covered its slopes; the open ground around was in places trodden over by wild game, the tracks of elephants and rhinoceros confused in those of herds of buffalo—some freshly made that morning; here and there the ground had been scraped up by bears in pursuit of the nests of the white ant, of which food they are extremely fond.

At Choppagoree there was no village, a square of sheds had been erected, and a few straw huts of more comfortable pretensions gave shelter to some of the officers; for myself I preferred a tent, as these places of general entertainment have usually a number of occupants small, exceedingly vicious and in great number.

At this place two officers went out with their rifles at night, hoping to see some animals emerge from the jungle at their customary feeding time at night; they told us that when the bugles in camp blew tattoo, the jungle was filled with the stamping and rushing of wild animals at the strange and unusual sound. Later they saw and wounded a bull buffalo, and saw a gigantic elephant, the circumference of whose footmark, twice told (the usual and very accurate method of measurement) would have given him a height of 11 feet.

The dew at night was here, as at all other places we had passed, extraordinarily heavy—the tents being literally saturated as if by a heavy fall of rain, and their greatly increased weight making their carriage a matter of difficulty.

From Choppagoree a short march of seven miles brought us to Sidlee, our approach to which place was marked by large tracts of rice fields heavy with grain, a narrow nullah, or little rivulet with steep, foul banks of loam and clay, gave us a sample of what we might have before us. The leading elephants trod the earth into a perfect swamp, and those behind had to use great exertion to free their legs from the sticky mass of deep mud; even men sank into it at places up to their forks—the banks above and below the spot we crossed were steep and deep in mud, fringed with high dense forests of null or nurkooll grass.

The Raja of Sidlee bears his kingly title by Bhootea sanction, he being a tributary of that country. Our advent evidently discomposed him seriously, and although cringing to the temporary invaders, he believed not in the stability of our power, and refusing us information, gave great trouble and annoyance; in several instances his falsehoods were proved before we had been many days in the country, but through all he bore the same meek, subdued, and slavish air that characterizes the Oriental, and which so soon changes to swagger and tyranny when the power moves to his side.

The village—it is nothing more—consists of about 60 houses, grouped under a picturesque clump of trees, on the banks of a clear, swift-running little stream, while miles around stretches the plain of waving grass, here and there the brown colour of the herbage which covers the drier portions becoming streaked by long lines of the nurkooll jungle, which, springing up from the low beds of old streams, bears its evergreen leaves in the hottest season of the year.

A present of milk and sweetmeats was brought into camp for the officers of the force, by the mookteah, or prime minister of his petty majesty; but the rice, which our camp-followers required for their food, was at first refused, and when sold, it was at such a ruinous price that the coolies, seeing their wages would be swamped by the ordinary necessaries of life, deserted in numbers.

In answer to our inquiries as to the existence of any neighbouring villages, we were informed that only a few deserted hamlets lay to the N.N.E., that emissaries from Bhootan had preceded us and taken the yearly tribute, leaving with it but a week before our arrival. The raja claimed the country from here to the foot of the Himalayas as his by right, and that the Bhooteas had reduced him from an independent prince to a vassal. These pretensions were put forward, no doubt, with the view of his claiming these lands should we hold the country finally, well knowing our policy of keeping up the power of native chiefs, under our protection and care, a policy introduced since the mutiny shook our empire in India.

To test the accuracy of the raja's statement as to the nakedness of the land, a reconnoitring party of 20 men, mounted on elephants, pushed towards the N.N.E. Passing a village which lay to the right of their track, and within view of camp, they first came upon an inhabited one of about ten houses, five miles off, and the same distance further on, their eyes were greeted by a large plain of cultivation, in which lay a straggling mass of some 80 houses, with every appearance of comfort and plenty; pigs, fowls, and goats abounded, and as for any houses being deserted, the raja's statement was falsified at once. This village was named Doorpergoan.

We obtained two guides to lead us to a village called Bowtee, said to be five miles away, and by a track which led us across the branches of a tributary of the Aye (if not the Aye river itself), at their junction, we reached that place—at one time threading our way through a mass of jungle-grass which rose high above us on either hand, as we were seated on the elephants, forming an arch overhead; so dense and impenetrable was this growth that the eye could not pierce one yard in any direction. Just before reaching Bowtee we had to cross about 100 yards of desperate morass, which was covered with stunted shrubs and high grass, in which our elephants floundered and struggled, now sinking deep in on one side, in their attempts

to extricate a leg; now rolling the other way with a groan of helpless grief, and anon trumpeting shrilly as the iron goad of the mahout was plied to drive them to greater exertion. The smaller animals are far the best in these places, they sink less deep, and are more active in their movements. It is interesting to see these vast creatures taking advantage of every branch to support them; now twining their trunks round a tree to lift themselves, now treading on a fallen piece of timber, knowing it presents a larger surface to the ground—again using their trunk as a fifth leg to rest on as they extricate their hind quarters. The riding during this time is not easy to five closely-packed men, on a guddee, or mattress of straw.

Bowtee had about fifteen to twenty houses, rice fields laying around; another village adjoined, but as we had to return nearly fifteen miles, it was advisable not to go further; we had seen enough to know that the raja of Sidlee's words could not be trusted, and that it would never do to see with other than one's own eyes. At this place, as at Doorpergoan, half the men appeared to be the worse for liquor, and one of our guides got wonderfully communicative and unpleasantly sociable.

We bought some fowls at Bowtee, paying double the market price of Sidlee, to show the inhabitants that the white-faces were unlike the Bhootea robbers, and we then returned to camp, When re-crossing the river I could not but regret that want of fishing-tackle prevented my casting a fly in the deep pool close above us, into which a swirling eddy swept, well knowing that all these rivers were full of the Mahsèr, or Indian salmon.

A state visit was paid by the raja of Sidlee to Colonel Richardson; the raja was a large fat man, oily and false, a true Oriental potentate. He came carried in a kind of sedan chair, attended by two gold sticks in waiting, and a tribe of obsequious followers. A present of a rhinoceros' horn was given to our chief, who showed by his manner that he was not best pleased at the raja's falsehood and insolence in closing his markets.

The point our force was making for was one called Bissen Singh, of which little was known, except that it lay in the first range of hills; as to what it was, a village, a town, a fort or stockade, or "no local habitation but a name," of this we knew nothing. We were told that between us lay no village, that it would take three days to reach it, travelling from sunrise to sunset; that there was no road, scarcely a track, which no one of Sidlee knew for a certainty, and that this path lay through a howling wilderness of forest, swamp, and jungle, or as they termed it, "bilcool jungle hye."

We were now told that we were here to await the arrival of Major-General Mulcaster, who after taking Dewangiri with his right column, was to cross to us of the right centre and personally superintend our forward march. This, as it would cost more than a fortnight's delay, was gall and wormwood to our anxious wish to proceed, as we had just heard of the success of the two columns of the left brigade, one of which had taken Dalingkote, the other Buxa, after a brush with the enemy. Besides, as the intended route of our column was kept secret, working parties could not be employed in making a road, as might have been done, right up to the foot of the hills. A road to the probable first day's halting place was made by our chief's direction, and so well did Lieutenant Garnault of the engineers perform this work that when we finally did advance, this march was completed with a celerity and ease most satisfactory to all.

During the time our force halted at Sidlee to await the arrival of Major-General Mulcaster, shooting parties pushed in all directions, always finding the same wide-spreading plains of waving grass, and to the east and south an occasional village of Mechees and Garrows. These two tribes are the only human beings who can, however feebly, withstand the terrible nature of the climate of the dooars at its worst periods, and the entire absence of an aged or grey-headed man shows how dearly even they pay for the possession of the soil, sharing the produce with the wild animals of the forest and the still more insatiate tax-gatherers of Bhootan. By the sweat of their brow and in terror of their lives do they till the soil and share its teeming fruits, for so rich is the land that the world cannot show a tract to excel these dooars in richness and luxuriance.

When the dense masses of jungle, the wild fields of rank vegetation, are cleared—when the rains are led off the soil and not allowed to form death-giving marches, then most assuredly will this country be a by-word in the east; the land being canalled by rivers, which would bear the produce to the banks of the mighty Brahmapootra, while forests of the most valuable timber cover large surfaces of land. A comparative fresh climate can be found in the low mountains that rise from the plain, and the high slopes of the Himalayas, with a climate unsurpassed by any on earth, are in the very view of the plains. Tea already gives large profits in the kindred district of Assam, whose only drawback is the inaccessibility of the hills; we hold the passes into these in our hands—surely no government will throw away the prize now in its very grasp, a prize that will bring millions of rupees into its treasury, open out a valuable and new district to English enterprise, and permit the reward of those who have toiled long and stoutly in her service.

The Mechees are a gentle, unwarlike race, easily satisfied with what supports life and scantily clothes their bodies; so are the Garrow tribes who come from the Garrow hills on the south and east banks of the Brahmapootra, but alas these inoffensive colonists have been but too often obliged to forsake their homes and fields owing to the intolerant oppression of the Bhootea; I saw many and many a deserted hamlet as I marched through the dooars, with every mark of having been but lately inhabited, while at times the surface of the ground showed spots which had once been squared out with cultivation, but where the site of the village was lost in jungle. The revenue paid by these villages varies considerably in different districts, and I take it that those nearest the hills suffered the most from the marauder, as it was in their neighbourhood that most of those deserted were seen. Mr Metcalf (the deputy commissioner attached to one of the columns) affirmed one day that the revenue paid by certain of the villages to Bhootan will be less than what is to be demanded by the Bengal government now; but one important item must be carried in mind, that the revenue is the only tax with us, while the supplies, presents, and bribes to Bhootea collectors formed not an unimportant item before. In the eastern districts of the dooars, the Mechees and Garrows complain of no outrages from their mountain masters, the slave-drivings and robberies appear to have been of late years directed chiefly against the petty raja-dom of Coorh Behar, but if these statements were believed, then in the Sidlee, Bijnee, and Rephoo dooars, the desertion of villages—especially that of the once large town of

Cutchabarry—would be unaccounted for; for from personal inspection I saw that the want of water for the latter place could have been remedied by a few men in a week, the old water channels leading from the Surrunbundee being still in existence and but slightly injured.

From Sidlee two routes led towards the interior of Bhootan by way of Bissen Singh, as the first point in the hills was named. The more direct route was said to be through jungle and forest, with a scarcely perceptible track, suffering from scarcity of water and abundance of wild beasts; it was said that even the Bhootea seldom traversed it, and he bore a high character for endurance and woodcraft. The other road led away from the direct route to the villages of Fagneeragoan and Dootma, and after a wide sweep to the S.W. to the foot of the mountains. The straight and less known path would take a single traveller three days, walking from sunrise to sunset; and from Pokeehaga (the name of some spot where the ascent began), it would take half a day, or as our informant expressed it, from sunrise to "there," pointing to where the sun would stand about noon—for the natives of Sidlee had but a vague and dangerous idea of distance. The easier path would, it was said, take six days.

As our column suffered from a scarcity of baggage animals, and as we would be obliged to carry our provisions with us any way, the shortest road appeared to have advantages, especially as the winter time was fast passing, owing to the delay of our having to wait the result of Major-General Mulcaster's operations against Dewangiri; besides, as either road was then a *terra incognita*, it was as well to take the shortest. So our practical chief, Colonel Richardson, directed the field engineer to clear the direct path, and in a short time Lieutenant Garnault was driving a wide passage through the dense wilderness of grass that spread far on our onward way. Working with a rapidity scarcely to be credited, this indefatigable officer soon cleared the dry growth of grass by a systematic plan of prairie-firing. Marking the direction of the wind and setting up marks on high, he fired the jungle, and miles upon miles of an impenetrable wilderness was soon so clear that a deer would have been visible at a mile's distance. Working parties under the sappers, well supported by armed parties, cleared through the burnt embers a 12-foot way, and before long an excellent road was completed to the spot which would mark our first day's march.

The appearance of these conflagrations was, at times when the wind was high, indescribably grand—a perfect wall of fire would travel with wonderful rapidity over the wide face of the country, with a roar quite appalling. Even when at a safe distance to windward the elephants would trumpet shrilly and tremble with fear at this revelry of their great dread, fire.

The arsenal of His Highness the Raja of Sidlee did not present an imposing, praiseworthy appearance. Two or three old honeycombed guns, of the smallest calibre, one burst at the first reinforce, lay just inside the gate, about which lounged some dozen Bengalese, not the most desperate of warriors. This armory was also the barracks of His Highness, it was full of spears with imposing-shaped heads and fringes of scarlet tassels; matchlocks more or less dangerous to the person using them, three of large bore and evidently meant as wall-pieces, and at the most, some thirty swords completed the warlike stores of the place. The powder (made at Sidlee itself) was of unequal grain, dead in lustre and filthily dirty: no wonder that

the unwarlike Bengalese and Assamese, armed with such weapons, should look upon the sturdily-limbed and swaggering Bhootea as the type of courage. Half a dozen of these daring mountain men, armed with nothing but their straight heavy sword, would drive whole villages before them, and carry off spoil and plunder, should the cowardly inhabitants refuse their demands; and all I can say is, "serve them right." Such pitiful, lying, intriguing cowards as the men of Assam and Bengal, could never become of consequence except as huxters and usurers; under the mild equable sway of English rule they grow wealthy and flourish, swagger with the boldest, and shoulder the bravest men as they pass.

The mookteah blew himself out like the frog in the fable when speaking of the Bhooteas, and informed us that they were men of desperate daring and great strength—great men, not like those of the plains, but "pucka jawans" indeed, sons of the giants. His fierce look, as he imitated his terrible masters, was supremely ridiculous, and did not sit well on his cunning, wrinkled old face, or become his weak and strengthless frame. The chicken-hearted inhabitants of Assam and the dooars looked with awe upon the more energetic and manly mountain men, who, however, had been painted to us by our own authorities as a contemptible enemy, cruel, false, and cowardly, unworthy of our steel. It seemed strange that mountain-bred men should be thus! for if the mountain breeds not stout hearts, where are they to be found?

While halting here we heard of the success of the left column, who had taken Dalingcote, after a sharp and trying day's work; but a sad calamity threw a gloom over the victory. Three officers of Royal Artillery and all the detachment who served at the only mortar in action, were blown up by the accidental explosion of a powder barrel. The engineer officer, Lieutenant Collins, was still alive but fearfully mangled; but three gallant officers, Captain Griffin and Lieutenants Waller and Anderson, were killed with many fine soldiers. Poor Captain Griffin's name appeared in the Gazette a month after his death; he was made a major for past services, his name having been omitted when others, and some his junior subordinates, were rewarded. Poor Griffin's hearty voice will be long missed by his old comrades-in-arms.

Our eagerness to get on was not decreased by hearing that Dewangiri had been occupied by the right column, but the accounts gave the whole honor to a party of forty police, under Lieutenant MacDonald, who pushed on by one of the four passes; while the main column, under Maj.-Gen. Mulcaster, was irretrievably confused in another. Lieutenant MacDonald found Dewangiri evacuated by the enemy, who, however, seeing the smallness of their enemies' numbers, returned, and throughout the night kept up an intermittent attack, killing and wounding ten or twelve of the police, but utterly failing in driving out or intimidating the gallant little party, under Lieutenant MacDonald.

Maj.-Gen. Mulcaster's force had toiled painfully and slowly up the pass, the elephants (which the General had decided on taking with him up the mountain road) delaying the rapidity of the advance, and the soldiers having experienced great inconvenience from having repeatedly to cross and re-cross the stream that followed the windings of the road. Towards the close of the day, the advance, on turning a corner, came suddenly upon a

stockade, built across the path where a sudden rise in the ground and the proximity of a large rock, offered an advantageous position. One shot fired from behind this breastwork, added terror to the astonishment of the leading files and the 43rd Assam Light Infantry, took to their heels and made a decided retrogade movement, trampling their officers under foot, and carrying anything but confidence to those in rear. The road was completely blocked up by elephants, camp followers and soldiers—night was coming on. The native regiment had shown their unsteadiness for that time, and so Maj.-Gen. Mulcaster determined to bivouac on the ground they then occupied, for that night, and those who passed the night there assured me that it was a most unpleasant period. The next morning a cautious advance was made, the breastwork found deserted, and the leading files of the column soon met a solitary policeman, who gave them the astounding intelligence that Dewangiri had been in the hands of Lieutenant MacDonald's party since the previous evening, and that that officer had gallantly repulsed the enemy's night attacks.

The column now proceeded rapidly and boldly, and occupied Dewangiri in force.

Maj.-Gen. Mulcaster, with two companies of the 43rd and two mortars, left that post under Colonel Campbell and the remainder of his column, and marching to join the right centre, whose steps we have followed as far as Sidlee. The force left to garrison Dewangiri consisted of the head quarters of the 43rd Assam Light Infantry, 2 guns and 21 Eurasion or half-caste gunners, about 40 Bengal Sappers and 40 police, in all about 400 men. The 43rd had already given an idea of their gallantry; they were recruited from a cowardly race, and had been on detached service for years, so that they had neither courage or discipline. The police were mostly men of the Kamroop battalion, which had been reduced from the strength of the army—men inured to active service, and naturally of a warlike class. The sappers were most excellent soldiers, and the Eurasion Artillery subsequently showed, that even in a disastrous retreat they kept their discipline and were amenable to order.

On the 28th December, Maj.-Gen. Mulcaster arrived at Sidlee, and orders were given for a review the following day in an open piece of ground before the village, which came off most satisfactorily; the cavalry, of which branch we had a large proportion, 2 squadrons of the 14th Jat Horse, and the same of the 7th Bengal Cavalry, performing a brilliant charge on the only open ground, between this place and the northern slope of the Himalayas.

The day following the review our force left Sidlee, and as we took the direct path to the hills, we found no difficulty in pressing onwards as the road made by Lieutenant Garnault allowed us to proceed at a rapid rate; the force consisted of a wing of the 12th and 44th, two companies of the 43rd, two howitzers, two mortars, with 40 Eurasion gunners and about 50 sappers; but of the mounted branch we had no less than 300 sabres, who led the column through the jungle.

The first halting place was named Bentool, and was about eight miles distant from Sidlee. On our way we crossed a clear, sparkling little stream, on the banks of which were a few grass huts used by Bhooteas when halting here; it bore marks of late occupation. Bentool had formerly been a village, and we saw the little banks of earth which had divided the paddy fields into

squares; but the whole country had become overgrown with grass jungle, which had been burnt down for our reception, and anything more filthy than the consequences cannot be imagined, for the blacks got through clothes, into one's ears, nose, and eyes, while the very taste of it was in our meals.

The only water available was got from a muddy, sluggish, reed-fringed stream, which at one place opened into a deep pond, where many of us cleansed ourselves from the mass of blacks which had made the white officers in complexion like unto the men.

Notwithstanding the road having been previously made for us, it took four hours to accomplish the eight miles: the march proving a peculiarly exhausting one, owing to the walls of grass on either hand having kept out the breeze, the absence of any shelter from the fierce rays of the sun, and the great scarcity of water.

On arriving at the encamping ground we had to make room for our tents by clearing the ground of the dense high masses of matted grass, and to allow an uninterrupted view to the sentries it was directed that a certain space in front and rear of each corps was to be similarly cleared of rank vegetation. Bill-hooks, reaping-hooks, and swords were soon hard at work, but two hours labour made so little impression on the dense and formidable growth of tropical grass that at length we employed elephants to tread it down. This gave us an unpleasant idea of the nature of the country we had to force our way through.

At 6 a.m. next morning (the 31st December) the force started, through an apparently endless forest of high grass jungle. As no road had been made we advanced at a minimum rate of rapidity; to the right and left rose a wall of grass into which a man could only dive with difficulty—a horseman was lost in the dense masses that reared themselves high over his head—he could neither see or hear, for the noise of his comrades breaking through the grass was great.

The three hundred cavalry led the column, and they certainly made the passage for the infantry comparatively easy, but the artillery elephants did the most towards marking the path of our force.

About noon—it is impossible to say how far we had travelled—a fire arose in the grass jungle to the south and westward of our march, and gave considerable concern, as besides the natural fear that elephants have of fire, we had a large proportion of artillery ammunition; however, the fire swept away in rear of us, and shortly afterwards we arrived on the banks of a river called the Borepanee, on either side of which there were occasional stretches of sand and stones.

A high bank, densely covered with the everlasting grass jungle, was chosen for the camping ground of the infantry and cavalry, and this was fired in places to clear it, but either through carelessness or inexperience the jungle was burnt in strips, and again the same harrassing duty had to be performed of clearing the grass jungle. At half-past two the force began to get their tents up, and I can answer that all were right ready for their meals. Throughout this marching and countermarching we seldom were able to break our fast before noon, often not before two or three p.m. At the request of their commanding officer, the artillery were permitted to encamp in one of the stretches of sand, and we were in comparative

cleanliness, while the rest of the force suffered from the plague of blacks. Permission had been given for the artillery to encamp where they did owing to the danger of fire, and it was indeed fortunate it was so, for the sunburnt strips of grass in the infantry camp caught fire, and many tents had to be borne bodily off to save them from being burnt; some were damaged, while the cavalry were in imminent danger from their horses taking afright from the neighbourhood and magnitude of the conflagration.

The rear guard, under Lieutenant Oldham, of the 12th Khelat-i-Ghilzie Regiment, had a narrow escape with their lives, the fire which we had seen about noon had swept down upon them, and the fortunate finding of a spot already cleared alone allowed them a place of safety; Lieutenant Oldham lost his sword in his flight, and unless I am mistaken, a native officer of the 44th N.I. was badly burnt.

As the evening closed upon us, the whole country around was in a blaze of light, the jungle having been fired in all directions, and we were begirt by a sea of flames. Mr Metcalf, the civil officer, believed that this was the act of incendiaries, and a picket declared they saw men in spots where the grass had just been lit: if it so was done, it was the deed of the followers of the raja of Sidlee, as no Bhooteas were near.

The danger arising on these occasions from the excessive terror of the elephants and horses was great, as they strove to escape from the neighbourhood of the conflagration, and had they once broken loose it would have been impossible to re-capture them in the waste of grass jungle that surrounded us on every side, and when the flames broke into the cavalry lines it caused a consternation not easily to be described.

The nature of the country was such that cavalry proved a hindrance, a source of weakness and delay, while the necessities of a cavalry man are great, himself, his horse, and grass cutter having to be fed, and as I have before mentioned, our commissariat officer, Captain Biggs, was already short of cattle for the conveyance of the provisions of the force.

While pitching our tents a terror-stricken deer rushed through the camp of the artillery and was captured by the men, giving them better meat than the half-starved bullocks on which they had usually to depend.

Early the following morning, the Deputy Assistant Quarter-master General, Captain Norman, proceeded ahead with an escort to reconnoitre the road.

At 11 a.m. the force marched, and we commenced to break through the tall grass as before; we had proceeded about one mile, just beyond a gigantic skeleton of an elephant lying by the pit in which he had been killed, when the word was passed from the front to go about and return to our old camping ground. This retrograde movement caused the greatest consternation to the camp followers in the rear; how the rumour originated it is hard to say, but it was said that the Bhooteas had attacked and routed the force, one man declared he had heard the whistling of showers of bullets. The go-about movement made a pressure behind, loads were flung off the bullocks, coolies dropped their burdens; there was a scamper and a route most complete, and, alas, calamitous, for it took hours before the fallen and broken loads of grain could be repacked in the Commissariat camp. The ground, as we returned, presented the appearance usually seen on the flight of an army.

The irregularity of such conduct was severely censured in Orders that

evening, and native camp followers were informed that for such behaviour they would in future render themselves liable to punishment.

One hundred of the cavalry were ordered to leave our force the following day, and proceed to the town where they had been directed to be stationed, leaving two hundred with the force.

The 1st January saw us off again to a camping ground eight miles distant; for the first four miles we passed through the same high grass as before, cavalry leading the column, and then we came upon a clear pebbly bottomed stream, on either bank of which ran a strip of forest, whose boughs overlapped and formed an arch above the water; this thatch was matted by gigantic creepers, festooned in a manner beyond description beautiful.

Four such streams did we cross, none above 2 feet in depth, occasionally a boggy bottom where the elephants sank deep, but these wise animals got through eventually, breaking down obstructing boughs and winding through the wilderness of trees till they formed a path which allowed themselves and their loads through.

The place where we were to encamp was a dense mass of tall grass beside a stream called the Dalpanee. To work officers and men went, cutting down the growth of jungle, two hours had done but little, and then we trod down the masses of grass which allowed us an open space to pitch our tents upon. The elephants did right good service, they would tear up the jungle and toss it on their backs, and carrying it off threw it away, one elephant doing the work of twenty men. Reaping the grass being out of the question, at length, as I said, we trampled it down and pitched our camp as best we might. Well may this country be called a "howling wilderness." Fever here began to shew itself among us; we had previously had many cases, which had nearly all given way to the remedies, but Lieutenant Garnault was now laid up, and a large proportion of the men.

The country certainly had an undeniable air of unhealthiness about it, but we were going on towards the enemy and thought but little of the matter, except when the stench of the rank vegetation made itself more than usually disagreeable.

The Deputy Quarter-master General and Mr Metcalf went on again from Dalpanee to reconnoitre the road to Bissen Sing, and to find the whereabouts of the once large town of Cutchabaree. Our guides were useless, and we soon found that the great obstacle to an advance would be the want of water for even culinary purposes.

The stream close by which we were encamped was full of fish, which attacked us savagely when we bathed, nibbling most unpleasantly at our legs, they took a fly readily and afforded considerable sport; they ran, about herring size, some even up to a pound in weight, and proved excellent eating.

Many wild elephants were here seen by the mahouts or elephant drivers when collecting forage, and rhinoceros tracks were quite common and fresh on the river bank, while deer marks were beyond number, but, to the sorrow of our sportsmen, a General Order was issued which prohibited going out on shooting excursions.

The reconnoitring party could only find a small streamlet of water in a place about five miles off, and as the quantity would not suffice for the whole force, the old right and left leg plan was again put in force, and Colonel Richardson, with the 44th Native Infantry, marched thither, where they had

to clear jungle, and camp themselves in a comparatively open space, in the midst of a magnificent forest which extended for miles on miles around them.

On the 6th January the left leg struck their tents on the Dalpanee (the cavalry leading), kept up that stream for 2½ miles, and then turned into a dense forest with an undergrowth of tangled tropical vegetation quite indescribable; here an infantry man might with difficulty have got through, but a horseman was helpless, he could not have gone one yard right or left off the track. We passed the right leg under Colonel Richardson, and encamped in the very midst of such a forest as can only be seen in Bhootan, or some other primæval wilderness. Gigantic trees rose out of thick masses of bramble undergrowth and thickets of young trees. The flags marking the regular intervals between the different corps were correctly placed, and we had to clear the ground between. Thanks to the assistance of the artillery elephants, we gunners did so with comparative ease, but even to us it was a labour of hours; the greatest nuisance being the number of little red ants, whose nests hung from the low boughs of trees, these, when disturbed, grew furious, and joining forces with swarms of black ones on the ground, attacked us unmercifully. These nests of the red ant were made of leaves joined together with mud, the whole mass being round, and the size of a melon, they were suspended from trees, and the vindictive little inhabitants bit with the venom of a wasp.

While clearing a patch of leaves we came upon an enormous lizard about 5 feet in length, and the thickness of a man's calf; him we soon despatched, as also a little red deer (the Muntjak) which ran into camp and was caught by the Eurasian gunners, who again fed on venison in place of tough commissariat beef.

The water we obtained here was scanty and bad, and Capt. Norman found even less ahead as far as he had gone.

At this forest camp a fire was thoughtlessly lit at the foot of a partriarchal tree, up the hollow of whose trunk the fire went with beautiful effect. As the fire increased inside, the sparks issued in picturesque bouquets from the orifice high up, while the rush of air up the cylinder gave out an interesting and harmonious sound. Now the tree spread its large limbs over my tent and that of my friend Capt. Briggs, and somehow we did not see the full beauty of the scene when it became apparent that our tents might suffer. So to work we went to stop the lowest end of the chimney, but matters had gone too far, the upper branches were on fire, and one or two fell, but those over our possessions held out. We then tried to fell the tree so as to let it fall to the far side, but the weight of the Damocletian boughs threw the centre of gravity our way, and finally we had to mourn the destruction of our tents.

The reconnoitring was so far successful that it told us that no water could be found ahead for twelve miles, and that the site of the old town of Cutchabaree could only be identified by the lime and orange trees, which were covered with fruit; so, warned in time, we carried water with us for the next day's march. We knew we must be near the foot of the Himalayas, but the dense forest quite obstructed any view.

Our march on the 7th was under the grateful shade of the forest for eight miles, to the spot where Cutchabaree had been; here the open space, once covered with rice fields, was overgrown with high grass, which rose up and

almost choked the lemon and orange groves which were covered with fruit; the marks of the old hamlets ran for some distance around, and the water-courses appeared in fair order. I feel confident that all the water for the use of this village or town was led in channels from the river which we came to, a mile further on, called the Surrinbundee, a clear beautiful stream, on the banks of which we came in full view of the mountains rising almost at our very feet, the deep bold passes seemed all alike difficult. On a high ridge in the front range we saw a two storied-house, with some magnificent trees overshadowing it. This, then, was Bissen Singh, where one of our frontier posts was to be established.

Every hill-side we saw was covered with forest, and a more difficult country to operate in cannot be imagined. The hills in the north-western frontier of India were as nothing to these, for they were accessible on many sides, were scantily covered with forest, had large plains intervening for our supports, commissariat supplies, and depôts, where a few cavalry could awe a multitude of mountain men; here all was steep mountain sides and deep gorges, all alike covered with forest. A country where none but free men ought to live, for

> "Be sure a great God never planned,
> For slumb'ring slaves a home so grand;"

where every mountain pass was more or less inaccessible to an invader, and where there was no booty to tempt the avaricious to enter.

Keeping close to the bank of the river, we pushed through low dried grass (which rose from a rocky and sandy soil), through open forest for three miles to where we were to be encamped, in a thick belt of briar jungles, full of trees, at the very foot of a densely-wooded hill, where, to make just sufficient clearing for our tents, employed all hands for three hours. The open stretches of dry short grass lying alongside our camping ground were covered with foot-marks of deer, while in the pleasant shade of the open forest parrots and other birds screamed angrily at this intrusion on their home. I took my rod with me when going to bathe in the river that afternoon, and in a few minutes caught seven fish of about ½ lb. weight each.

The following morning, the 9th January, an advance was made on Bissen Singh by 250 men of the 12th and 44th Native Infantry; the pass was one which could have been held against us by a few men, the forcing of it would most assuredly have cost us a heavy loss, more especially had breast-works or stockades been erected, but there were none of these defences, and the five miles of steep ascent were safely accomplished—the rise could not have been less than 1000 feet above the camping ground.

Bissen Singh was found to consist of a large strongly-built stone building of two stories, built on the summit of the first range of mountains, commanding the pass entirely; the road to Cherung, apparently a very good one, was seen winding round the hill sides towards the north. Two of the well-known shaped Bhuddist tombs stood near the house, as also a small range of sheds, evidently the dwelling places of the Jungpen's retainers. From one of these came a dirty, weak-eyed, old monk (of "Orders Grey"), rosary in hand; he had a crick in his back, and the most unpleasant effluvia. As he did not know Bengalee, Assamese, or Hindostanee, and no one attached to the force knew Bhootea, the amount of information gained from this individual was very limited.

Orders were given for Bissen Singh to be placed in a defensible state for the occupation of 200 of the 44th Regiment (Native Infantry); accordingly the jungle was cleared round about, walls levelled, and stockading erected, a work of considerable time; but the position was so strong that, when once completed, it could, with such a garrison, have held out against 2000 men. The only question of difficulty was that of water, but this was to be had about 80 yards below the position, and a protected path was finally constructed to enable the garrison to draw water safely at all times.

In levelling one wall only, over 100 scorpions were destroyed, so an idea may be formed of the number of these venomous insects, and the well-known filth of the Bhootea made the occupation of the two-storied house a matter of doubtful expediency, as it had the appearance of being numerously inhabited.

Close by this house was a group of magnificent trees, a level earthen platform under it had been formed for the convenience of loungers; the view around was truly beautiful, waves upon waves of wooded mountains to the north-east, north, and west, and the wide stretching plains, unbroken by a single hill, running towards the horizon to the south, the yellow winding strip of grass marking the line of the Surrinbundee river, a thread as of silver, in the centre of this strip, shewing the river itself; the air was fresh and cold, and after the toil of the ascent, the view and sensation were equally delightful.

We found out that this place was simply the winter palace of the Cherung Jungpen, who, when at Bissen Singh, employed himself in fishing in the stream below, at Pokeehaga, where our camp was pitched, Pokeehaga being the name of a large rock in the river bank.

While the force remained here, waiting the completion of the stockading round Bissen Singh, many of the officers went out shooting, and often met with wild animals. I paid attention to the river, which literally swarmed with fish, and my success was considerable: the first day I caught 37, which together weighed 8½ lbs., the following day I caught 26, which weighed 17½ lbs., and as I began to learn the pools where the larger fish lay, I landed bigger ones, often two at a time, weighing together 5 lbs., this, as the tackle was light, scarce, and very weak, satisfied me; the largest was one of 4 lbs. In thirteen days I killed 208 fish, weighing 115 lbs., adding an agreeable item to our indifferent diet.

When fishing, it was always necessary to go well armed, as the sudden appearance of an enemy was not an impossible contingency, this put one in mind of the old campaigning days during the mutiny, when snipe shooting, we would walk the jheels or bogs with revolvers and swords on, and not unwisely, as more than once we came in sight of the Sepoys.

Twice I tried for larger fish by trolling, and had the satisfaction of losing all my tackle when a monster of the deep took the bait.

On the 11th, Maj.-Gen. Mulcaster and his staff left the column, and, with the escort of the 43rd Assam Light Infantry returned towards the east for the general superintendence of the frontier posts, which at this date were all in our hands, after a few days operations and an almost bloodless resistance. Those who had upheld the policy of annexing and holding this tract of country with but a small force, could now triumphantly point to the ease with which the result had been gained, and indeed deride the increase of the force which had been made solely on the representation of high military authorities.

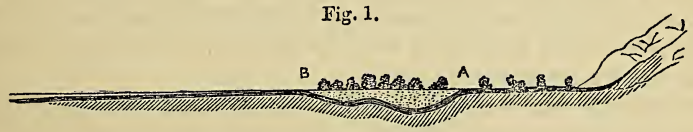
The 20th January saw the English forces in possession of all the passes and posts—the whole tract of the Dooars in their hands—and this little war was presumed to have come to an end; a month more, and with the exception of Dalingkote, every one of these posts were again in the hands of the Bhooteas.

But to return: on Sunday, the 22nd, our little column bade adieu to those who were to be left as garrison at Bissen Singh, this detachment consisted of 200 Ghoorkas under Major Dinning; they were well supplied with ammunition and three months' provisions; the garrison could have held the position against any odds, they were men, as before-mentioned, bred in a mountainous country, who had been well schooled in hill warfare; but, alas! no medical officer was available, there being only one for the entire column.

Our return march lay by a different route than that by which we had come, we found it a less savage country, void of habitations it is true, but we had not to pass through the same dense forests that we had penetrated before. The first day took us to a spot which we designated Bumpa Hill, we reached it by following the course of the Surrinbundee, until this river disappeared below the surface, when we kept by the bed over a most disagreeable road of boulders, windfalls, and gravel, equally bad for riding and walking, and most trying to the elephants, the tender soles of whose feet became bruised and painful, making their pace a very slow one.

This disappearance, to a considerable or entire extent, of all the rivers which flow from the Himalayas, can be accounted for in two ways; either the soil is of a sandy and porous quality, allowing the water to sink through and form a subterranean lake or bog, as shewn in Fig. 1, or else the floods of years have

Fig. 1.



thrown up a supersoil of rock, stone, and sand through which the water pierces, keeping a level, as it is unable by the laws of nature to run up hill, Fig. 2; whichever theory is correct, it is this stretch of country, from *A* to *B*, which is the most deadly, be it here in Bhootan, or in the terrain of Nepal and Rohilcund.

Fig. 2.

At our halting ground, the springs of water which had risen to the surface a few miles back, began to form themselves into little rivers, full of deep pools, literally alive with small fish; our camp was formed in a network of these streams, at the foot of a hill, covered with a dense vegetation and forest. Many went out in the hope of meeting wild game, but none was seen, although the fresh spoor of elephant, rhinoceros, and buffalo covered the land in every direction—the noise of the camp being pitched had scared these animals away. This day, however, I shot a fine

samber stag, he passed me when fishing, but my gun being at hand, I grasped it in time to fire before he reached the sanctuary of the opposite bank. His appearance, as he broke cover and bounded across the river from rock to rock, was magnificent, his horns laid well back, and his thick ruff of hair falling deep down over his throat. I ought to mention that the want of water during the "dry" portion of this march was severely felt by the Sepoys and animals, the day being very hot and close, it killed a noble wolf hound dog belonging to a native officer of the Jat Horse. Our next march was to Dewagoan, about fifteen miles, no water for about eleven miles, all suffering exceedingly in consequence, a tract of country like that of the day before, wastes after wastes of dry grass, with stretches of forest, all scorched and burned; we passed the body of a dead rhinoceros. When we at length did meet with water, there was seemingly no end to rivers and brooks, which we had to cross and re-cross some twenty times just before arriving at Dootma, a pleasant little village of Mechees. Mr Metcalf, near this, had caught six Bhooteas and their wives, of whose neighbourhood the villagers had given information. The principal man of these seemed to be above the common class, by the deference paid to him by the villagers; he had beside the usual straight sword, an English-made percussion single barrelled gun, with a flask of Hall's powder and a tin box of Joyce's caps. He was an intelligent man, spoke a kind of Assamee Bengalee, and thus, through an interpreter, we got much interesting information. The women were remarkable for their ugliness, and, like the men, belonged to the order of the great unwashed.

There were wide open plains (around Dootma), with excellent bustard shooting; a tiger carried off no less than three bullocks from the very midst of our camp, at night, and we accordingly made up a party to kill him, but he broke away by an unguarded spot and escaped. The villagers speak of many of these animals being about.

On information received regarding the existence of a Bhootea guard-house called Rephoo Chung, some 20 to 25 miles to the north-west, a party of 110 Sepoys were ordered to proceed there. Colonel Richardson himself accompanying, from whom I obtained permission to go also.

On the 25th January we left Dootma, and marched 6½ miles to a village called Goosagoan; it consisted of about sixty houses, and contained a separate clump of Bhootea huts, all built on piles, the lower story being used for cattle and pigs only. Their little colony was surrounded by a stockade of open work, from 13 to 15 feet high; we passed several villages on the way with extensive rice fields adjoining. At night the screaming of pea-fowl round the village formed a most discordant chorus.

The next day we passed through four miles of cultivated land, and then came the old belt of high grass, tree-jungle, and forest, without the least sign of water; when we had completed about twelve miles we emerged upon a wide dry river bed—the water having sunk below the surface as before explained—in full sight of the mountains which rose about two miles ahead; we toiled over the rocks and boulders for about two miles more, when we saw perched on a little plateau just above the river, which had a little water in it, the stockade and guard-house of Rephoo Chung, around which rose some ten high poles with little flags thereon, and nailed on the poles were yards of Bhuddist prayers printed on calico, calling upon the

demons of the mountains to annihilate the cursed invaders. Magnificent timber grew around the plateau, and the background of densely wooded mountains formed a lovely picture.

We found but one man, with his wife and two children, in the place, and a number of pigs and pigeons; by a round-about system we heard news, the system was this:—the Bhootea, a fat gross man, told the Bhootea who had been caught at Dootma, he again spoke in Assammee to one of Mr Metcalf's officers, who in turn communicated the matter to Mr Metcalf in Bengalee.

Expecting an advance of British troops in this direction, 400 Bhooteas had assembled to stop our entering the pass here. They had remained full of determination for a month, and then as their provisions fell short they retired inland. The pass into the interior led to Lotko and Loormaghat—the former a simple halting place, the latter a guard-house at the only practicable crossing over the Guddàdà; even here the passage of the river was said to be a most dangerous matter, and on each bank stood a guard-house, the possession of which would necessarily command the road on either side. About 60 Bhooteas were said to be still ready to resist us. Rephoo or Zephoo was reported to be a very healthy situation; inside the stockade were three large wooden double-storied houses raised about 10 feet above the level of the ground; outside the stockade were two other huts, and the ashes of another lately burnt down. This post did not command the pass, as it might be passed on either side at night, or even in day time, it being some distance from the entrance. The stockading was 12 to 15 feet high, strongly built, but open, allowing a complete view of the interior, and, I should fancy, was quite untenable; at night a few matchlock men from the neighbouring forest, not 80 yds. off, could commit great havoc among the garrison; these, not knowing the strength of the assailants, would not dare to leave the protection of the stockade, and if they did, would on any future occasion be open to a similar annoyance.

The following morning early, a reconnoitring party of 300 men pushed up the pass towards Lotko and Loormaghat, the first six or seven miles the pass was comparatively open, the hills on either side rising to about 500 feet, all thickly wooded, a stream of water was the only road, which, with the stones and boulders, soon destroyed our boots; the soles of mine came off before we got far, and, like the rest of the troops, I suffered terribly, my feet becoming cut and bruised. Following some lately made footprints, we came upon a little hut which had only been just left, a wooden platter still containing food for the day before.

Keeping to the left, where the ravine divided into two channels, we pushed on, the pass becoming more and more confined, and at length so much so, that the cliffs fairly overhung the path, rising 300 to 500 feet perpendicularly over head. Had our advance been disputed here by a dozen old women throwing down stones and rocks, we should have had difficulty in passing: one hundred men could hold this ground against ten thousand. There being however no sign of an enemy, we advanced, the scenery being grand in the extreme; the path at times was lost in the dry bed of a torrent, up the huge water-worn rocks of which we had to clamber, occasionally requiring the use of both hands. At the head of the torrent bed a good open road, zigzagging up a steep hill, commenced, and here Colonel Richardson halted us, he having seen the utter impracticability of ever forming a frontier

post so far up a pass of this description, and wisely not risking an encounter with an enemy who would of a certainty be posted in a strong position, when even success would to us be of no utility. We therefore retired, and were even more struck, when on the way back, with the grandeur of the scenery and the immense strength of the pass.

The plateau around Rephoo Chung was cleared completely, all the outhouses but one were razed, provisions for two months were left for the police detachment of 30 men who were to garrison this post, and on the 30th January the remainder started on their return to the main column. I should mention that the fat Bhootea was permitted to inhabit his outhouse; this man could read, and had undoubtedly been left behind, when his countrymen fled, to be able to give information of our doings. We had by his means arrived at the contents of a letter which Mr Metcalf had received at Dewangari, from the Dhurm Raja; it was to the effect that we should not delay sending him the tribute due, or he might be obliged to write again, that he was straitened for cash, not having received the tax from other portions of his kingdom, and he drew particular attention to the red seal attached to the document. On finding who the writer was, our fat friend of Bhootan raised the document to his forehead with an air of the deepest reverence and respect.

On our return to Goosagoan we made for the village of Dootma, where the main column were supposed to be, we found the intervening country consisted of about eight miles of mostly well cultivated land, with many apparently well-to-do villages, the plains well intersected with streams, one of which gave us considerable trouble in crossing, the banks being of soft clay and loam into which elephants, ponies, and even men, sank deep. The Bhooteas who had been captured by Mr Metcalf at Dootma, were here permitted by him to depart with their wives and a bandy-legged little dog who had quite taken a fancy to the white-faced men; these Bhooteas declared that they dare not now return to the mountains of Bhootan, as it would be believed that they had played the part of traitors and would assuredly lose their heads, they therefore decided to inhabit the stockade at Goosagoan, the inhabitants of which village appeared nothing loth to have them, the Bhooteas being adepts at distilling liquor and cunning hands at mixing tobaccos.

My health had up to the present been on the whole excellent. At Jogeegopah and at Sidlee I had had slight attacks of fever, which left me after a few doses of quinine, but now, at Dootma, I got a sharper attack, inaugurated, as it usually is, by hours of shivering ague: it is an abominable sensation, and quite took away any pleasure derivable from the march, which brought us to the villages of Faquaragoan, Putnabaree, and Chapur, on the 1st, 2nd, and 3rd days of February respectively. The marches were of 10, 13, and 8 miles, and the country was of the same description as that we had met on the road from Jogeegopah to Bijnee. The even surface of the plain, broken by the uprising of little mountains densely covered with the jungle; streams, and rivers innumerable intersecting the country, nine-tenths of the surface of which was covered by tropical grass in which wild animals swarmed. Now and then we would come to a deep nullah, or ravine of water and mud, into which the elephants would sink helplessly, the passage of which would much delay our column. Occasionally the plains of high rank grass would

be succeeded by stretches of a lower kind of grass, and by extensive fields of rice cultivation. At Chapur we had to cross the Chumpamuttee river on rafts, and in the cool water of this river enjoyed a refreshing bathe, in spite of the presence therein of numerous gigantic alligators.

The 4th February saw us in our old ground at Jogeegopah, across which a violent wind was blowing clouds of dust, which filled our tents and rendered writing or eating an exceedingly unpleasant occupation. The post brought us intelligence of Dewangiri having been attacked on the 29th January by a large force of Bhooteas, who, at about 3 a.m., had stolen past the pickets, sword in hand, and attacked the camp, killing and wounding many of the native servants who lay outside the tents, and cutting at the tents themselves; when expelled from the camp they kept up, from outside, a heavy fire of matchlocks which killed Lieut. Urquhart, of the Royal Engineers, and 5 Sepoys, and wounded Lieut. Storey, of the 43rd Native Infantry, and 37 Sepoys. The attack had long been expected, and the enemy shewed great skill and courage in the way he passed the outlying pickets, and attacked the camp. Reinforcements had been sent towards this post, but had not arrived up to the 31st, on which date the enemy had erected a stockade in a position commanding Dewangiri, and from which the 43rd Native Infantry had been unable to dislodge them.

A further reinforcement of two companies of the 12th Regiment, Native Infantry, was sent from our column, besides cavalry; but on the 7th February we heard that Dewangiri had been abandoned and the guns which had been attached to the right column lost in the retreat. The reasons assigned for abandoning this post were the difficulty of obtaining water, the want of communication, and the indefensible nature of the post.

It is well to mention here that the guns abandoned were not Armstrong guns, as the English periodicals have so sturdily insisted; they were not, though employed in the mountains, guns intended for that kind of warfare, being heavier than any of that nature, viz. of 3 cwt.; they were, I believe, identical with those employed for boat service in the Royal Navy. Their great weight rendered it a matter of impossibility that they could be moved on mules' or ponies' backs, or carried by a few men when slung on poles, they were therefore entirely unsuited for mountain warfare; the fact of their being obliged to be carried on elephants, at once rendered them an impediment to a rapidly advancing or retreating force; even broad-shouldered powerful English gunners could with difficulty have carried these pieces of ordnance, and the weakly light-framed Eurasian was quite unequal to the task.

From the very steady behaviour of the detachment belonging to these two guns,—who carried away wounded men abandoned by their own comrades, and who, even when deserted by the escort of the 43rd Native Infantry, given to them as a protection, still kept their discipline,—there can be no doubt that had the guns been of a nature to admit of being carried by hand, they would not have been lost. As an artillery officer I feel bound to make this statement, in order that this disaster may be attributed to its proper cause.

As it was not unlikely that Bissen Singh had been attacked, our chief, Colonel Richardson, determined to communicate with that garrison, more especially as we had heard no news from them, and our little force, now only consisting of about 300 men, returned, *viâ* Chapur and Faquaragoan, to

Dootma. We were visited by several heavy showers at this time which cooled the air, but made the carriage of our tents a trying matter to the elephants; these animals were shewing the effect of insufficient fodder, the grass being of a nature to cause dysentry; the particular trees on the leaves of which they feed, being always scarce and sometimes unattainable, they had consequently grown thin, several had died, and others had broken loose and escaped to join their wild brethren in the forest.

At Faquaragoan we found in a hut, bundles upon bundles of letters, which had, days ago, been thrown away by the post carrier. From these we heard news of Bissen Singh, that frontier post had also been attacked. The old dirty monk I spoke of as having been there, had employed his hours of prayer at eve, in chanting aloud, not praises of Bhudda or lamentations for his sins, but in singing to friends outside the stockade intelligence of all going on inside. He had thus informed them that about noon daily, 100 men of the garrison were employed in carrying up the pass the provisions from Pokeehaga, that 50 men were employed in cutting timber to strengthen and complete the stockade, leaving but a few as garrison, of which some were at that hour cooking.

The never-sleeping little Ghoorkas had, however, heard noises in the woods on the morning of the 29th January, and reported it to Lieut. Udney and Major Dinning, who sent to find out the cause; on this messenger returning in great haste with positive news of strangers being in the forest, the assembly was sounded, but no sooner had the first notes been given, than there arose a yell and a rush from several hundred Bhooteas who had collected all around the stockade. The guard of Ghoorkas, however, were not quite unprepared, and commenced firing, whereupon the enemy retiring under cover of the surrounding wood, sent flights upon flights of arrows into the post; they soon, however, had enough, as the fire of the 44th Native Infantry increased every moment, and at length the enemy drew off. Major Dinning decided not to follow as he did not know the strength of the enemy, nor had he sufficient men to garrison the place besides.

The stockading was literally filled with arrows, but only five men were wounded, and these slightly. The fear of the arrows being poisoned soon subsided, as no immediate ill effects were remarked. Swords, bows, and belts, with many marks of blood, were found in the woods, and men were distinctly seen being carried off by the road which led towards Chemny; in one group of these was seen stalking the monastic-garmented old monk.

Col. Richardson, with an escort, left Dootma for Bissen Singh (taking ammunition and stores), to see that the post was sufficiently strengthened to resist any more determined or lengthened attacks; and more especially to see that all necessary arrangements with reference to a good supply of water were made.

On the 16th February we heard that the Left-Centre Column had been driven out of its frontier post at Tassagong, in the Bala Pass, with considerable loss, so that it was evident that almost simultaneous attacks had been made upon us by the Bhooteas along the whole frontier, and it reflected great credit on them, whatever it might upon us, that in two out of three attacks the "ill-armed, despised Bhootea" had been successful.

On the 20th of January we had held possession of every post that we considered it desirable to possess, before a fortnight from that date we had

been driven from two of the most important; and as orders were now sent to Col. Richardson to withdraw from Bissen Singh and Rephoo Chung, and to take all his force to join the Right Column under Maj.-Gen. Mulcaster, we actually, at this period, had but two posts left, namely, Dalingkote and Buxa. So much for undervaluing an enemy, who "was found to be daring, full of courage, numerous, and not ill-armed;" (though he had been painted "cowardly, enervated, small in numbers, and miserably-armed"). Whatever terms may be applied to the tactics and conduct of the British forces, it is but just to give the wild Bhootea credit for the few good qualities he may possess.

On Col. Richardson's return to camp from Bissen Singh he found awaiting him the orders to destroy and retire from the posts formed by our column, which had been held intact, and instructions were given accordingly. I myself received orders to proceed to the command of an Armstrong mountain battery, which was attached to the left-centre column, that which had been driven from Tassagong, and though laid up for the past three days with a bad attack of fever which had left me unusually weak, I obtained leave to proceed at once to the new appointment.

There was a difficulty, however, about getting to my destination; the only known way was by Gowalpara, where I should have had to wait, perhaps for a week, for a steamer going to Doobree, from whence it was seven long marches to the Bala Pass. This would perhaps take me 14 to 20 days, a period I could not give, as it was highly probable our force at Bala would attack Tassagong shortly, so that although the country intervening (only 60 miles in a direct line), was entirely unknown, not an Englishman having ever been through it. After weighing it over, I decided it would not take me *longer* than the round-about way *viâ* the base of operations, and therefore getting two men from the village of Dootma (who, however, denied all knowledge of any path), to assist me, I set off on the 22nd February. The jungle fever had, however, taken such hold of me that I could not leave my bed; the hours of night were the worst, sleep being quite out of the question, and my head swimming with the quantity of quinine it was necessary to take. To make matters worse I had a week before sprained my ancle badly, this was swollen and angry, notwithstanding repeated applications of leeches; I was quite unable to walk. When I started on the 22nd, I looked anything but a valuable addition to a fighting force.

Three Sepoys and a native non-commissioned officer were given me as an escort, and two elephants were allowed for the carriage of these men, and for their kits and provisions for 10 days.

At starting the two *guides* again protested against going, declaring with wringing hands they had never been westward, and that the country in that direction was a howling wilderness; a promise of £1 a piece had a good effect in calming their despair. Having a compass, and knowing that my journey was as due west as I could make, I set forth, but for the first few miles was constantly stopped by the repeated remonstrances of the *guides*, who implored to be allowed to depart, but as my whole hope lay in them (and the little compass), we soothed their fears, excited their cupidity, and succeeded in persuading them to try their skill in finding a path.

Passing for three or four miles by the same route as led to Goosagoan, we

then kept slightly away from the hills, leaving the cultivated land behind, and entered a wild tract of grass jungle, now and then coming to a water-course on the banks of which grew belts of trees, and passing the village of Dahnbaree, we came after a march of thirteen or fourteen miles, just at sunset, to the deserted village of Kissenbaree. The inhabitants of this place had evidently not left many weeks before, as the platters, sieves, and other household utensils lay about quite uninjured; the partitions between the houses and rooms were unharmed, the floors evenly plastered, and the path-ways free from grass; however, the harvest had been entirely gathered in and removed. This village consisted of about twenty houses, a clear little stream of water flowed close at hand, and on its bank, half a mile down, just at the side of the path leading southwards, were erected a number of little miniature houses, the supposed dwelling places of the village deities. Fearing that the village might swarm with vermin, notwithstanding its cleanly appearance, and to keep near the water so as not to necessitate the distant straggling of our little party, I chose the idol village to rest in, and slept in one of its little huts, the remainder of the party sleeping around; and verily the sacrilege of so profaning the habitation of the Hindoo deities was avenged, for the mosquitoes attacked me most savagely, and between this nuisance and the throbbing of my ancle, I had but little rest. This plague of mosquitoes always brings on an increase of fever.

At the earliest break of day we rose and commenced to cook our morning meal, not knowing what might happen to prevent our eating that day, having been taught by that severe master, experience, never to commence a day's work on an empty stomach. Striking due west, we passed through a country covered with low grass, the plains of which would have allowed splendid galloping after pig; these plains were intersected by clear streams of water, bordered by dense belts of forest a hundred yards in depth, very difficult to pass through, as the roots of the trees were often raised above the muddy ground, into which we sunk deeply; dense, high tiger grass, (called null, nurkool), fringes the immediate bank; the water in these five streams never exceeds three feet in depth.

Marching for seven hours without rest brought us suddenly upon a patch of cultivation, and a village on the far bank of a stream. This was the village of Mackta Goan, and here I obtained the assistance of an intelligent villager (the head man) to guide me further on. About a mile and a half in a more southerly direction brought us to the very extensive old bed of the Guddàdà, which held but little water. A mile beyond we came upon the present channel of this large river, on which I was fortunate enough to find a raft, which took my pony, my escort, and myself across, while the elephant crossed at a ford further down. The river was here about 100 yards across, and its greatest depth about 9 feet, flowing very rapidly, the water very clear and cold.

I forgot to mention that the pathway from Mackta Goan to the old bed of the Guddàdà was literally torn up in many places by the stamping of bull buffaloes, done only the night before, while new droppings of these animals, covered every open piece of ground on the way. The number which inhabit these jungles must be incalculable, and I quite felt the justice of the villager's complaints over the depredations they must commit.

Immediately we crossed the Guddàdà we entered upon a highly cultivated

country, for many miles the view was one of groups of villages under the shade of the banana and toddy trees, these were collectively called by the name of Bholkagoan. The sun was by this time very strong, the elephants and ourselves considerably exhausted, so I called a halt, sent for some of the villagers to bring refreshments, to give me information, and rested for two hours.

The villagers, on hearing of the arrival of a white man, came in numbers to see me, bringing fruit, sweetmeats, and milk. They told me that a force of the Company Sahib Bahadur, was two long days' journey off, and complained most bitterly of the oppression they had suffered from their Bhootea masters. The town of Hooldeebaree was my next point, and a guide was given me to show the way there. I was much pleased by the behaviour of the men of Bholka, who strove to assist me in every way, and to repay whom, for their welcome gift of fruit and milk, I had great difficulty, they long refusing payment for what they had brought.

One of my escort, a grey-headed Sikh, who had fought against us at Moodkee, here obtained some opium; the unfortunate man had become quite miserable, and exhausted from the want of this narcotic, an incredible quantity of which he daily consumed; when unable to procure opium, he languished, refusing food, quite unable to sleep or rest, becoming physically unfit for any kind of work. No sooner had he indulged in the noxious narcotic than he brightened up, sang aloud, laughing heartily at his previous incapacity.

Being sufficiently rested we started again, taking a direction about N.N.W., through a country far less overgrown with jungle, than any I had yet seen in the Dooars. Both to the right and left lay villages; two streams we passed were bridged, and at nightfall we came to the village of Coomergoan, which was divided, by a stream of about 2 feet deep, from the village of Hooldeebaree. Animals and men being thoroughly done up, I determined to rest here for the night, in a little hut standing by itself in a group of trees by the wayside. The villagers of Coomergoan, whom I sent for, gave me very contradictory accounts; one man who had informed me of the neighbourhood of a party of Bhooteas, afterwards refused to say more or to confirm his previous statement. The Sepoys of the escort said that there was some mystery and begged me to be cautious. After an hour's cross-questioning it was told me that the Bhooteas had repeatedly visited Hooldeebaree, indeed, that some houses erected there lately had been burnt down, that one villager had been killed and sixteen carried off as slaves, and this only three or four days before. This was pleasant kind of news, especially as the party of Bhooteas who committed the outrage were said to be at Soonkermuck, a place, the exact distance of which I could not find out, except that a man could easily go there and return in the day.

After considering the matter, I determined to keep hostages with me from among the men of the neighbouring village; these men and their friends were informed that I was to receive immediate notice of the approach of any Bhooteas in the night, or that instantaneous punishment would fall on the said hostages if any attack was made on me. I was well aware that if the villagers laid out proper scouts no one could approach me without being seen by them, and I knew that the four Sepoys and myself could keep fifty men at bay as long as our provisions lasted. About 8 or 9 p.m., a police-

man who had been following me from Dootma with a letter caught me, and I felt glad at this addition of a stout well-armed man to my party, the more especially as great excitement was apparent among the hostages and their friends, who now came forward and warned me of the neighbourhood of armed bodies of Bhooteas, they also explained all about the late raid, and inveighed bitterly against the Bhootea robbers, telling of slave drivings and murders; this was interpreted to me through my mahout or elephant driver, who spoke both Assamese and Hindostanee.

We cooked our dinner, and one man was placed at the ford, some 200 yards from our camp. About midnight the village next to us, about a quarter of a mile distant, was seen to be on fire, and we all stood to our arms expecting an attack; roof after roof caught fire, and for two hours the conflagration raged. At last I stole out, and creeping by some ditches came within 200 yards of the village. Men and women were screaming and wringing their hands, and some ten or twelve men stood apathetically by, never attempting to stay the flames. They were, however, not dressed like Bhooteas, but most undoubtedly were emissaries or adherents of the enemy.

Not liking this neighbourhood I packed up my traps before daylight, and keeping the party well together made tracks to the westward. Two guides from the village of Coomergoan, said they would lead me in two days to where a force of the "Company Bahadors" was assembled.

As the day dawned we found that we were close to the foot of the hills, within four miles of our front rose the wooded sides; the whole country around us for miles was cultivated and dotted with villages, then we came upon two branches of a large deep swift river, one of which I crossed on a raft; on the west bank of this river, called the Ryeduck, the cultivation changed, and we entered a dense tangle of forest and jungle, through which a path had been lately cut, which marked our way plainly enough. Seven hours of uninterrupted marching brought us to an opening in the forest, in the centre of which lay the deserted little village of Mezpara, close to it ran a pleasant little stream where we made half an hour's halt for refreshing man and beast. My ancle all this day pained me most villainously and was getting angry and hot, laying it in the cold running water refreshed it immensely. Some three hours more marching from Mezpara, through a wild grass jungle, brought us in view of some villages lying right and left of the track, and to what I understood to be an old fort. It looked more like a tank, but I did not go near, fatigue overcoming curiosity. From hence began a succession of deep ravines, having from 2 to 4 feet of water with muddy bottoms; twice my pony had to swim, and the elephants experienced difficulty in getting up the banks. This delayed us very much, and towards half-past four p.m. I halted again. We were all now thoroughly dead beat, and would have remained here for the night had the guides not been continually telling us that "the army lay encamped close by," and so they got us on, mile by mile. While eating some biscuits at the last halting place, one of the Sepoys came running to tell me that two Bhooteas were walking towards us, so ordering the men to hide, we suddenly pounced on our victims, but found that they were in possession of two passes for safe conduct, and were in fact employed to do some service for our government, collecting wood and building bridges. These passes were given by a Captain Hydyut

Ali, the principal officer of the Rajah of Cooch Behar's troops, a very intelligent and able native, who had been for many years in our service.

We let the friendly Bhooteas go, and, pursuing our way, arrived about 6 p.m. at Chichakhatta, where I found assembled the contingent of the Rajah of Cooch Behar, under the said Captain Hydyut Ali, who was most pleasant and hospitable. He had about 300 men of every nation and race in India whom he was drilling into shape, and it is but fair to record the untiring zeal shewn, and the hardships borne by the men, without a murmur. One portion of this force, the cavalry, performed an unexampled amount of work, shewing the same devotion and daring that had gained them an undisputed renown, when serving our own government under the title of "Rattray's Sikhs." As post carriers, they were exposed to continual surprises and ambushes, but never hesitated in their duty, and at times two or three, and these sometimes sick with fever, would have to remain for weeks, nay, months, on detachment, miles away from support or succour, open day and night to attack, from overwhelming numbers of the enemy.

Captain Hydyut Ali expressed himself astonished at the length of my day's march, which he put down at thirty-six miles. I had been nearly twelve hours doing the distance, and most of it had been at a good pace. Deducting two hours for halts and stoppages, and putting our pace at three miles an hour, it would give a distance of thirty miles, which I should think was about it, through a country hitherto untrodden by a European.

As Captain Ali promised me an escort further on, I sent back the men who had brought me thus far, and gave the Dootma guides their reward; as a reconnoitring party of cavalry was to proceed next day to Huldeebaree and Lunkermuck, I had no hesitation about their returning through the "disagreeable neighbourhood" under so good a protection.

On the 25th February, after breakfasting with Captain Ali, I started by the road the Left Centre Column had taken in their advance, which had been in existence for many years, probably many hundred, and had been the old line by which the commerce of Bhootan reached the plains of India at the end of the last century. This road was clearly marked and often upon a high embankment, passing through magnificent forests of timber as it approached the foot of the hills.

At the foot of the Himalayas, at a post called Myna Gong, about fourteen miles from Chichakhatta, there was a detachment of the 3rd Ghoorkas, and a considerable depôt of provisions, &c., &c. A sawar, one of Rattray's old Sikhs, came in while I was here, he had been waylaid while carrying the post from Bala Pass, by about forty or fifty Bhooteas, who dashed at him from ambush and seized his horse's bridle; but, using his spurs, he broke away, though not without several sword cuts.

The ascent from this to Buxar was by a mountain path, leading for two miles through wood, which at length allowed a full view of the mountain ranges, and raised one to the cool air and fresh breezes which render the climate of the mountains so delightful a change from the still deadly calm of the hot plains. The road was peculiarly good, and shewed how great the thoroughfare must have been in the old days, when the trade between the two countries was in existence. It was easy of ascent to both elephants and ponies, there were only one or two nasty portions in

the whole ascent. There were the marks of the old stockades which had been erected to stop our advance, which most certainly they would have done, had thirty men made a determined stand. But the Bhootea defenders were few and undecided, the Ghoorkas who attacked bold and active, and this dangerous pass was forced with but little opposition. The possession of Buxar and the heights immediately around, closes the pass totally.

On turning a corner, I came suddenly in sight of the tents and house of Buxar, placed on a plateau, on a hill, in the centre of a hollow, the heights around rising to a considerable altitude; all these, with the exception of one, being out of range of musketry fire. This one, however, completely commands the plateau on which our camp stands, and the possession of it is, therefore, indispensable; a strong work of ours is placed on this height, which lies to the right as you ascend. Another stockade commands the height on the left, while a third work closes the road up the pass. The occupation of these heights necessitates a stronger garrison than would otherwise be necessary, and the neglect of this at one time, was on the point of obliging our force to retire from this post also, so greatly had the strength of the garrison been reduced, and Buxar was once all but evacuated. On a height, by which the road led into the interior, high above our position, and looming immense against the sky, rose the Bhootea stockade, built against steep rock-work, and in a position peculiarly strong by nature; it rose in tiers one above the other in strange irregularity, flags being conspicuously placed all over it, and the face of the rocks made still more inaccessible by being boarded. They are busy at work up there now, and the enemy can be seen carrying planks and beams, as if they had made up their minds we should go no further.

This stockade of theirs must be one thousand feet above Buxar, a steep pull before beginning work; it seems a place, too, not easily reached by artillery fire, except at a long range and firing at a great elevation. But this is a matter which may improve on acquaintance. The whole scene looked business-like.

At Buxar were stationed the 3rd Ghoorkas, under Major Saunders. An attempt had been made, about a fortnight before, to drive the Bhooteas from the stockade, or, perhaps, to be more exact, a reconnoitring party, had gone up, who were, if it was found practicable, to destroy the work. Two officers, Lieutenants Gregory and Kingscote, were wounded, and also several men. The work was found in a very inaccessible situation, and the Bhooteas resisted determinedly, so with the paucity of numbers at their service, the Ghoorkas had to be withdrawn. The arrows shot by the Bhooteas were discharged with great force; in one instance the head had to be withdrawn from the shoulder of the wounded man by the iron being screwed into a vice and literally torn out, the thin soft arrow-head had turned round and round the shoulder blade of the unfortunate man, who, however, soon became convalescent. Our own troops were busy strengthening the three outposts, that which immediately commanded the plateau and position of Buxar, was especially being cared for.

Buxar itself consisted of a large two-storied stone house, substantially built, with carved verandahs on the upper story—this was now used for a hospital and as officers' quarters—the troops were encamped in tents on the plateau. Great difficulty was found in providing grass for the horses and commissariat

cattle. With reference to the latter, I might mention that a deputation of the Ghoorkas, who are high caste Hindoos, attended upon the Commanding Officer with a request that he would prohibit the killing of cattle, as such was hurtful to the prejudices of their caste. It is perhaps needless to say that their request was unattended to, as the health and comfort of the English gunners of the force had likewise to be considered. Of course sanitary precautions recommended that no slaughtering of animals should take place within the lines of the encampment.

Finding that General Tytler was shortly to arrive at Bala Pass, I left for that post the next day to receive orders from him, and so descended from Buxar in company with Lieutenant Stead, of the 11th Native Infantry. We obtained an escort of some of the Rajah of Cooch Behar's troops, and amid a torrent of rain, turned westward from Mynagong, and after fourteen miles from the latter place, through forest and grass jungle, arrived at a post called Nuttoobaree, where a relay of irregular cavalry was placed for the purpose of carrying the post and despatches backwards and forwards. There were only three men here at this time, and the severe duties imposed upon them, and scrupulously carried out, reflected the highest credit upon them. They were all Sikhs of the Rajah of Cooch Behar's force, men who had served the English government in Rattray's Corps. One of these three men was prostrate with fever, indeed, in a highly dangerous state; I gave him quinine and reported the case on arrival at camp, when he was brought in. I only mention the fact to do honour to these uncomplaining soldiers, upon whom fell the hardest of all the hard work in this campaign.

The fact of these men living thus by themselves many miles from any other post, and within easy access of a night's raid from the hills, struck me as making their quarters more exciting than agreeable. We had passed on this day's march the place where the letter-carrying orderly had been attacked the day before, indeed, it was evident that a party of Bhootea's were "out." The mosquitoes here were numerous and hungry, my companion and I fought against them savagely all night, and had but little rest.

At seven o'clock the next morning we were again on our way through a jungle-covered country, which presently showed signs of cultivation, and at a village called Malingee, we found a strong detachment of cavalry. Two more villages, both deserted, we passed on our way. At Malingee, some 9 or 10 miles from the Bala Pass, Lieutenant Stead pointed out to me the white cliff or landslip which marked the enemy's position in the first range of hills at the entrance to a valley. Presently an imposing looking structure became clearly visible on the summit of a hill, and this we found was a high two-storied fort which the Bhooteas had lately built, commanding the village of Tassagong, the post from which our force had been driven a month before.

Our force consisted of about 200 of the 11th Native Infantry, about 350 of the 30th Native Infantry, 4 Armstrong guns, and 2 small mortars, with English gunners, also a squadron of Irregular Cavalry. These were encamped in the stony dry bed of a river (the Torsha), about a mile from the mouth of the pass; the whole right side of which (facing us), on which face lay Tassagong and the road into the interior, was covered with stockades, which I will hereafter describe. The hill-sides were covered by dense masses of forest, almost impervious, and altogether the natural and

artificial means of defence at the Bhooteas' disposal made the general view quite encouraging to those who liked a hard day's work.

On the 28th February, General Tytler arriving in camp, we found that we were to await the arrival of the 19th Native Infantry (500 strong), and 200 of the 18th Regiment Native Infantry, and that then we were to try our fortune on the Pass in front, at strengthening which, the enemy worked unremittingly; as we could plainly see the whole ground in front of the works had been cleared of all upright trees, and those which had been felled were placed as abattis to retard our advance.

The high stockade on the summit of the hill was the most imposing, its height was 16 feet, the lower 8½ or 9 feet was backed by 4 feet of stone, and flank defence was given by four verandah-like galleries above. A fort similar to this was in course of construction at the top of the gorge. Below this, on the road in the gorge itself, was another stockade. On our left of the top fort, and on the ridge immediately above the landslip, was another work, the ground between these two being apparently even, and free from jungle or shrubs; they were about 500 yards apart, the landslip stockade being but little below the level of the top fort, and, therefore, when once in our hands, a fine position for our guns to be placed in should the Top Fort have to be breached.

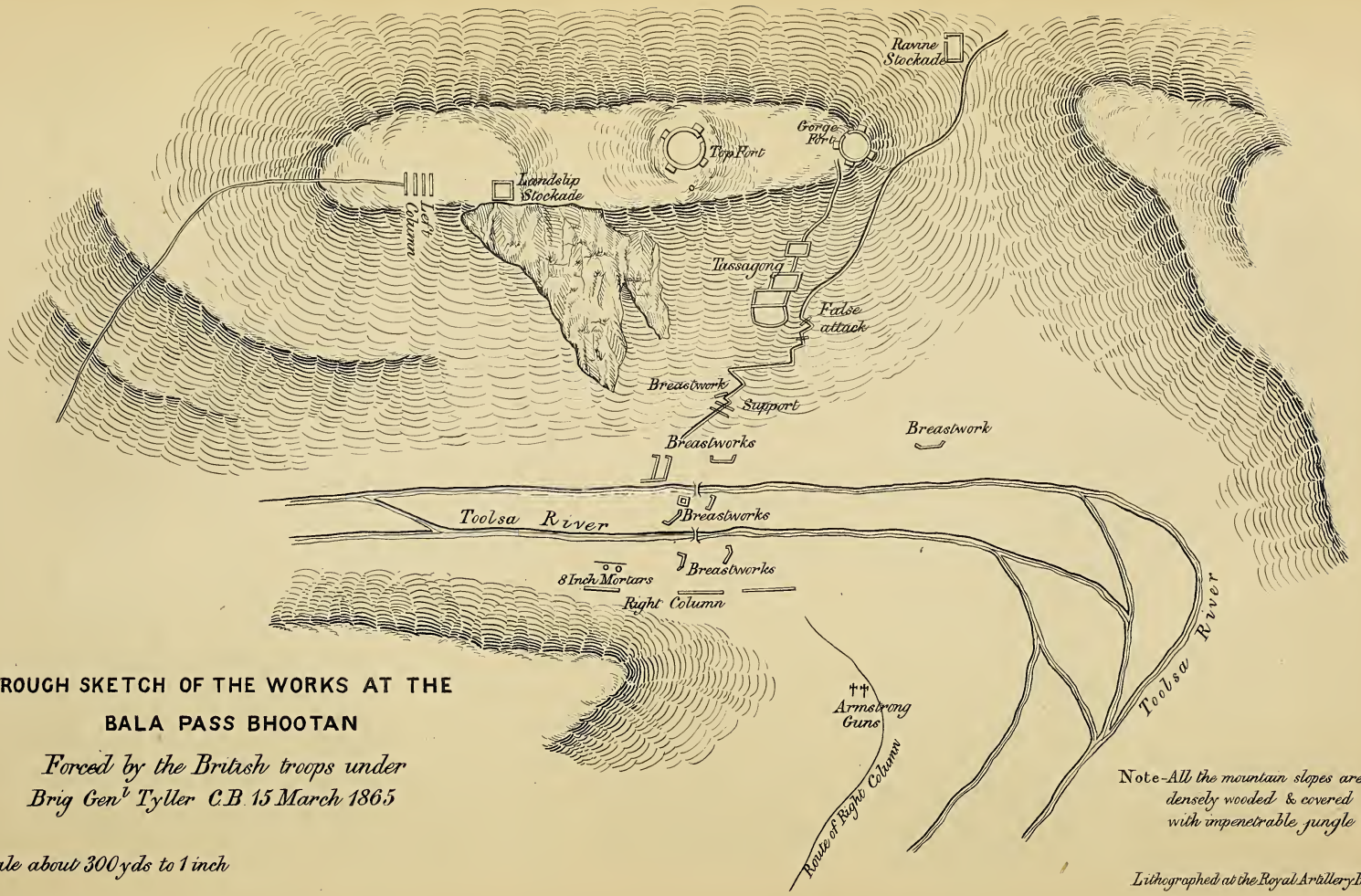
Tassagong, itself a village, lay below all these works, and had three distinct lines of defence, one above the other; all, however, were commanded completely by the Top Fort. Lower down again there was a clearing in the trees, and smoke rising as if another work was there also; while down low, close to the river, we knew there were two more breastworks which would fire upon an advancing party going up the river bed. In the dry bed of the river, built of stones, were several breastworks on both sides of the two bridges which crossed the river here, and the destruction of which, by the Bhooteas, would considerably retard our advance, as the river was waist deep and very swift, and only fordable at a few places.

On the 2nd March the enemy turned out in considerable numbers, carrying flags of all colours, and marched from the upper works to Tassagong, round and round which they paraded, firing and shouting. A temple has also been built in front of the Top Fort, and this many of the Bhooteas passed in single file, receiving something, what, I do not know, from some officiating priest or officer, but which, we subsequently heard, was to render them bullet proof.

While waiting for the reinforcements I tried my luck at fishing, and the first day was successful in getting two fish, one of 8¾ lbs., the other 6½ lbs.; they gave me good play, the tackle being light, they were both taken on the spoon.

On the 14th March, the enemy had completed the new fort in the gorge, and as if aware that we intended to attack soon, burned down all the dry grass and shrubs round the works, and appeared to be rather more numerous than usual.

The same day, the reinforcements for which General Tytler had been waiting, arrived at a point a few miles from our camp, and from where they would diverge when ascending the watercourse, which led them to the attack of the enemy's right flank. This column consisted of the 19th Native Infantry and detachments of the 18th, with two Armstrong guns and two



ROUGH SKETCH OF THE WORKS AT THE BALA PASS BHOOTAN

Forced by the British troops under Brig Gen[l] Tyller C.B. 15 March 1865

Scale about 300 yds to 1 inch

Note-All the mountain slopes are densely wooded & covered with impenetrable jungle

Lithographed at the Royal Artillery Institution

5½-inch mortars, making a total of 700 men. The path leading round this flank had been reconnoitred by an Engineer party, and also by Lieutenant Cameron, Royal Artillery, and although rugged and bad, it was deemed practicable. The heavy beds supplied according to the regulations, with the 5½-inch mortars, were found to be quite beyond the weight possible to be easily moved over bad mountainous ground, and Lieut. Pratt, Royal Artillery, had two others made, which, not half the weight, were proved by experiment to be amply strong for all practicable purposes.

To screen this flank movement by the above column, a direct attack was to be made by the remainder of the force consisting of the 30th, and a detachment of the 11th Regiment Native Infantry, two guns of the Armstrong battery, and two 8-inch mortars.

At 4 a.m., on the 15th, the force in camp at the Bala Pass got under arms, they were preceded by a party of 100 men, who were to seize the bridges over the Toolsa, if still intact and undefended by the enemy; if held in force, the party was to occupy the adjoining heights and prevent the destruction of the bridge by a close fire. The bridge was not held nor was an enemy to be seen. On the General's arrival, this party, under Lieutenant Webster, was sent up the direct path towards Tassagong, to reconnoitre and make a false attack, so as to draw attention from the flank to be attacked by the other column, and whose arrival on the heights above was anticipated at about half-past 9 a.m.

This party, under Lieutenant Webster, nearly succeeded in surprising the enemy in Tassagong, they approached by the path to within 50 yards, and the place appeared deserted, until two Bhooteas came out and leisurely walked up the ravine unnoticing our proximity. The steep and wearisome ascent had caused the party to straggle slightly, and it being decided to make a rush with the bayonet, a pause was made to collect as many of the men as possible and to take breadth. The word had just been given to fix bayonet, when the Armstrong guns in the valley below opened fire, and the works of Tassagong instantly buzzed with life. The first shell passed close over the heads of the reconnoitring party and burst inside the stockade, and with it arose the hum of many voices, shouting and calling to arms. This took far less time than writing it, and the possibility of a surprise being now out of the question, the party was withdrawn, but the Bhooteas had rushed to their works and opened fire on our men, who were, however, soon out of range beneath the brow of the hill and hidden in the brushwood, retiring with the coolness and quietness of veteran soldiers, only firing occasionally when an enemy exposed himself above the works. Captain MacGregor, the Brigade-Major of the force, and three Sepoys, were wounded; and the object of drawing the enemy's attention to this attack was eminently successful, as numbers were seen to leave the upper works and enter Tassagong. But for the unexpected shot fired by the Armstrong battery there can be little doubt but that the enemy would have been surprised in their sleep by this party, and great slaughter have been made among them.

As soon as the guns and mortars were in position in the valley, they opened fire upon Tassagong, and the accuracy of the fire was beautiful. Every one of the 8-inch shell from the mortars fell inside the work, and the segment shells were seen to burst just within the stockading, but the Bhooteas held stoutly to the place, and they could be seen moving about unconcernedly, though, as we afterwards discovered, suffering from a heavy loss.

The Landslip, Top, and Gorge Forts were out of range, but the capture of these was left to the column whose appearance we momentarily expected.

The morning was very lovely, the trees and vegetation budding and freshening anew into life, and the scenery one of uncommon beauty; at our feet ran the clear rapid waters of the Toolsa, and beyond its stony bed rose up a steep wooded hillside, the colouring of which varied from the brightest green of spring vegetation to the deep dark hue of the foliage of the evergreen. The white walls of the Landslip glittered in the sun, and the ominous-looking stockading and forts of the enemy crowned the most prominent heights above. The presence of the force, the varied uniforms of the different regiments—the scarlet-coated Pandy, the green of the Ghoorka, grey of the Patan and Sikh, and the blue of the Artillery, gave life, while the boom of the mortars and sharper report of the Armstrong seemed quite in keeping with the character of the whole scene.

Suddenly our attention was attracted by a glimmering of bayonets in the open ground in front of the Landslip Stockade; the advance of the left column was rapid and successful, a rush was made, and the above work instantly surrounded, but not before we saw several Bhooteas fly therefrom, and puffs of smoke issuing from the work. At the same time a shout arose from the enemy in Tassagong at this sudden appearance of our troops in so totally unexpected a quarter.

But let me return to the left column, which, under Major Ruggles, had been toiling the whole night to accomplish their march through the water-course and up the hill path by the appointed hour the following morning. The road was worse than was anticipated, and so slow was the pace maintained by the elephants and coolies attached to the artillery, that the infantry, leaving an escort with the guns, pushed on alone. The artillery, left without the assistance of the sappers to repair the path, were scarcely able to progress at all.

The infantry, however, at last came in sight of the Landslip Stockade, and, as expected, the ground was found to be open, level, and peculiarly advantageous to an attack when compared with the difficulties that attended a direct advance up the steep and strongly stockaded road to Tassagong.

The Landslip Stockade was carried at once, and a rush immediately made towards the Top Fort, the key to the position. The Bhooteas never flinched; the small garrison inside fired upon the Sepoys, who, however, soon scrambled up the almost inaccessible sides of the fort, their bare feet giving them a great advantage over their English officers, who, in boots, could not find so good a footing in the crevices. Once inside, no resistance was offered by the Bhooteas, who, I regret to say, were killed to a man, it being impossible to check the savage bloodthirstiness of the Patan and Sikh.

No sooner was the capture of this fort beheld by the enemy who held the other works, than they fled wildly; but before they left Tassagong, that strongly stockaded place had been set on fire by a shell, and the flames soon reduced the place to cinders.

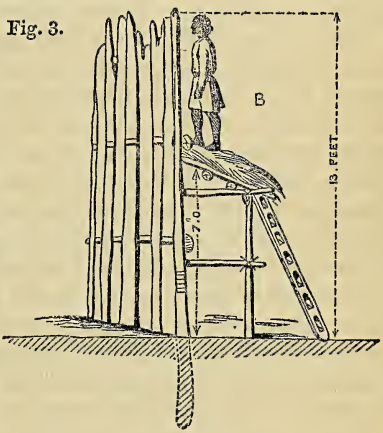
Our loss was, 3 killed and 15 wounded; and that of the enemy, 37 dead bodies found in the Top Fort, and 18 in Tassagong; the latter killed by the reconnoitring party, and by the fire from the mortars and Armstrongs. The wounded had been taken from Tassagong, but the marks of blood along the paths showed that there must have been a large proportion of these.

The strength of the position, against any other attack than that carried out, was very great. The works had been placed in the most advantageous positions, and General Tytler had reason to feel satisfied with success having been so easily bought. An advance in any other way must have cost a serious loss of men. The left column camped on the hill around the forts they had taken, while the remainder returned to camp.

I will now enter more minutely into a description of the stockading, which, on close inspection, was found not to be of so insurmountable a kind as a distant view would have led one to anticipate. Throughout, there were few places which were not open to escalade, for the face of the work, however high, always presented irregularities to admit a man placing his feet, and getting a hold with his hands. The Top Fort had, actually, hanging down its sides, ropes, of thin strips of bamboo, to assist the ascent of our men; and, even with their boots on, several English officers scrambled up without the assistance of these strips of bamboo, and yet the face of this fort was perpendicular.

The stockading at Tassagong is best explained by the accompanying Fig. 3, which shews that two lines of fire were obtained, the garrison using the lower portion under the thatched banquette as quarters to live and sleep in, placing a strong matting where the rear uprights are placed. The timber used was all cut by the Bhooteas' swords, and their woodcraft made one long for such men as pioneers in our own army. There were, in Tassagong, distinct lines of defence, three in number, each one of which could be cut off by closing strongly-made doors; loopholes bore from the upper into the lower of these works, so that the capture of a portion of Tassagong would not necessitate the fall of the whole village. The ladders leading to the upper line of loopholes were all made alike of squared posts of timber, with deep holes cut in at distances of a foot apart. Meat (of the buffalo), and meal were in abundance, also great numbers of the wooden bamboo platters and dishes for eating from, but all the flags but one had been removed by the Bhooteas before they fled. In Tassagong was placed a catapult over the only portion of the ground in front not visible from the work; a cleft in the hill-side running down the steep face at the spot. The level ground immediately in front of portions of the work was covered with innumerable pieces of sharp-pointed bamboo, stuck firmly into the ground and slanting outwards; these would seriously retard the advance of an enemy with naked feet. These "panjees," as they were called in the vernacular, were greatly in vogue among the Cossiahs, a mountain tribe on the Eastern bank of the Brahmapootra whom I before mentioned as having given occasion for an expedition being sent against them in 1863–4.

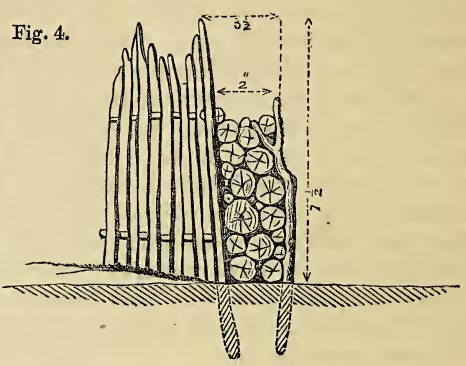
Fig. 3.



From Tassagong, the ascent to the Top Fort was enfiladed by the fire from the Gorge Fort and Ravine Stockade, and, in addition, strong breastworks of timber crossed the path at two different points.

The works at Tassagong were not intended to resist the fire of artillery, as was the one of the Ravine, where the sides facing the west and east were of great thickness; this stockade was unfinished, and the construction of it, with the intention of resisting the fire of our guns, can be accounted for by the fact of a reconnoitring party having, the week before the attack, penetrated towards this side of the defences, and drawn off after exchanging shots. The Bhooteas, fancying this might be our route, had evidently prepared to resist our attack from their left flank; an abattis of dense thorn shamble covered the front of this ravine stockade, and the rugged, steep ascent would have made an attack on this side a severe one. Two lines of fire were directed towards the west, that side of the stockade being occupied as a residence, an upper story having been added. The east face was incomplete, as shewn in Fig. 4.

Fig. 4.



Figs. 5 and 6 will, I think, shew plainly the construction of the building which I have called the Top Fort; that of the Gorge was on precisely the same plan, but was not quite finished. The lower portions could not have been breached by the little Armstrongs under a considerable amount of fire, and the carriage of a large amount of ammunition up the ascent for such a purpose would have caused much trouble and loss of time. Though narrower at the top, the wall of stone at the base was from 8½ to 9 feet in thickness, and very strongly

Fig. 5.

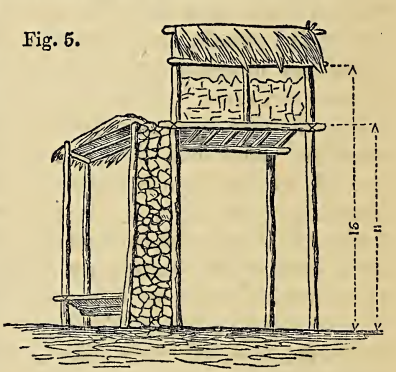
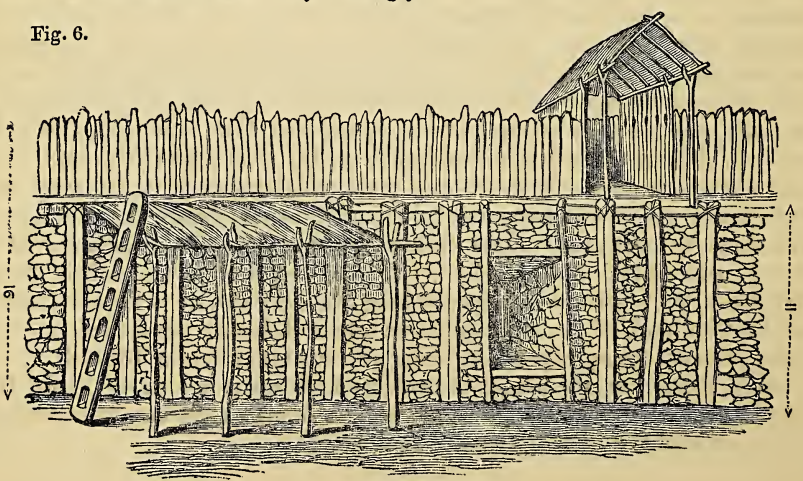


Fig. 6.



bound by uprights of stout timber. The exact intention of the four enormous loopholes in this stonework I cannot conceive, as it presented an equally good, if not better, opening for external firing, for the sides of the loophole increased inwards, therefore a man could be hid while loading when without, while the whole interior was swept by the fire from the loopholes crossing one another. The sides of the galleries giving flanking fire were of MATTING, so that they could not be made use of without great exposure to the "flanker," while the supporting posts could have been pulled away by a number of men.

The Bhooteas never dreamt that men would attempt to scale so high and apparently inaccessible a work; this can alone account for their remaining inside when the attacking party rushed towards it, and certainly a distant view of the work would lead one to believe their idea correct.

While our troops advanced the Bhooteas fired upon them, causing the loss which we suffered, but the moment they found that their enemy was inside the work they gave up the contest and suffered themselves to be killed.

The interior presented a disgusting appearance, set aside the marks of the fight. Huge joints of buffalo meat, stores of flour, lying about covered with clouds of flies; dirty remnants of clothes, dirty cooking vessels, foul wooden platters; and immediately outside the walls the general latrines of the Bhooteas. The scene, taking into view also the distorted, mangled, stripped corpses of the slain, was one sickening to look at. How different the scene when one stepped outside and saw the glorious hand of God in nature, and then to think of what the hand of man had made within.

The day following the forcing in the Bala Pass, I employed myself in taking sketches of the works and of the country around. To push further into the interior of the country would necessitate an immediate descent on leaving the works which we had taken, as the path led down again to a little tributary of the Toolsa river; but from information we had received it would appear that no other steps had been taken by the Bhooteas to oppose an invasion into their country.

On the 17th March a message came in from the enemy to say that they would, in exchange for the dead bodies of their friends, give over to us those prisoners which they had taken in the previous portion of the campaign; these prisoners consisted of one Sepoy and three camp followers. These men were reported to be well taken care of and in health—a fact reflecting disadvantageously upon our men, who, in the late fighting, had ruthlessly killed every Bhootea, even when resistance was over.

A chief, of considerable importance among the enemy, had been slain in the Top Fort, and when his countrymen came to remove his body they actually wept over it; he was a fine tall muscular man, with very fair complexion.

As the works above Buxar were to be attacked at once, the Armstrong mountain battery, under Captain Wilson, was sent on the 18th March, *viâ* Malingee and Nuttoobaree, as the services of these guns were greatly relied on, their practice having been so satisfactory in the late business.

At Buxar, an apparently extensive and strong stockade had been erected since I was last here, on the summit of a high hill above the stockade which commanded the road leading into the interior, and which a

month previously repelled the attack made on it by a party of the 3rd Ghoorkas.

At General Tytler's request I ascended the crest on the left of our position, above the Bird's Nest Picket, for the purpose of finding a comparatively level piece of ground on which the $5\frac{1}{2}''$ mortars might be placed for shelling the enemy's works. We found such a spot 700 yards from the lower and first built stockade, but the path leading to it was very precipitous, indeed well nigh impracticable. We were seen by the Bhooteas, who fired a shot as if to give notice of our neighbourhood.

The following day I went with Captain Wilson on a similar errand, by the crest on the right of our front, and after a long stiff ascent found an excellent place for either the Armstrong guns or mortars, from which the ranges would have been 700 yards to the lower, and not under 1500 yards to the more distant stockade. We got into the regular road and descended by it to the camp, and found it a capital one, passable for laden elephants.

This day the enemy sent to General Tytler to say that they had no wish to fight, but that they would obey what orders he might give them. General Tytler thereupon ordered them to destroy their stockades or he would do it for them. The lesson taught them at Bala had had its effect.

The attack was ordered to take place the next day, and to be by our right flank, a false attack to be made by 200 men of the 3rd Ghoorkas, who were to advance by the crest on the left of our position, and cut off the retreat of the enemy by getting possession of the road in rear of the stockades. The main attack was to be made by nearly 900 men, consisting of detachments of the 3rd Ghoorkas, 19th and 31st Regiments of Native Infantry, and of the Rajah of Cooch Behar's contingent.

On the evening of the 22nd the enemy appeared busy at their stockading, but what they were at could not be exactly decided; however, during the night, men were seen walking about with torches, and when the advanced party of our troops had reached the neighbourhood of the stockades, flames were seen issuing from them, and we had the mortification of seeing them wrapped in flames as we rushed into them, only to beat an instantaneous retreat, so fierce were the flames and so successfully had the stockades been fired.

The party of the 3rd Ghoorkas forming the left attack, were just too late to cut off the retreat of a large body of the Bhooteas, who yelled loudly as their enemies came in view, but whose advance they did not choose to dispute.

This position was a far stronger one than that at the Bala Pass; the artificial defences, however, were not of so elaborate a description, but owing to the very advantageous formation of the pass, it would most assuredly have cost us a heavier loss in taking it. The highest work on the summit of the hill was almost inaccessible, excepting by the narrow tortuous path which was completely commanded throughout its ascent, and the whole surface of the ground around was covered with "panjees" or stakes of sharp-pointed bamboo. The road leading to the lower stockade was quite barred by impenetrable masses of felled trees.

I accompanied a party of Ghoorkas and two Engineer officers, who pushed on about five miles along the road into the interior; we were now at an elevation above the sea of probably 5000 to 6000 feet; the air was cool and

agreeable, the vegetation was that of the temperate zone, violets and other wild flowers speaking to us of our own far-away home. Magnificent forests of trees covered the slopes of the mountain, and gave us a grateful shade. When about five miles from the head of the pass on which the enemy's highest stockade stood, we came to a ridge running across the road; this ridge, on the other side of which the road descended again, was well adapted for a sanatarium, the slopes being easy and the distance to the plains not over ten miles. Wood was in abundance, and the presence of a supply of water was rendered probable by our finding a pond of considerable extent; from this ridge we obtained a glorious view of the sunny range.

This was a very hard day's work, and the exposure brought on an attack of fever which left me very weak.

Having obtained permission to proceed to the right column, far away before Dewangiri, on the extreme east of the Bhootan frontier, I was anxious to get there at once before it should be attacked. General Tombs had succeeded Maj.-Gen. Mulcaster in command of the troops there, and an English regiment, with an English battery of artillery, were on their way to join his column, to render as certain as the chances of war would permit, the re-assertion of our superiority of arms, and to retrieve the disaster suffered by the English in being driven from Dewangiri.

On the 24th March I descended from the hills on my eastward journey, in company with Mr Gray, a gentleman of independent fortune, who, with an Englishman's love of adventure, was travelling the world around, and who at Bala and Buxar, did his best to get shot by always keeping with the most advanced party; we arrived together at Chichacotta, where I was again laid up with a severe attack of fever which, however, abated towards evening.

The colony of Bhooteas at this place turned out and gave us specimens of their war cry and praying. Anything more inhuman, more fiendish in its character, than the former, cannot be conceived, it approached more to the yelling of jackals and hyenas than anything else I had ever heard.

Their prayers were chanted first by one man in a monotonous key, and then the whole party would join in, gradually raising their voices and increasing the rapidity of utterance. Their prayers were a repetition of the Bhuddist expression, "*Una mani padme hun.*" A sentence repeated on every sign and on every piece of parchment, engraven on their temples, and forming the sole, and, even to them, unintelligible burden of their worship. Antiquarians and men of science are alike unable to trace its meaning.

The following day I was again prostrate with fever, and arriving at Cooch Behar, fortunately found shelter in the tent of a medical officer, but having a repetition of the attack, and feeling quite unable for so trying a journey as that towards Dewangiri, I accepted the necessity of going to Calcutta.

I remained at Cooch Behar for a few days, until a change in fever gave me a little strength, and then proceeded to Doobree, three long marches, which, having to be performed alone and in a broiling sun, was about as trying a performance as any I ever underwent; each day halting under any chance shelter that presented itself, with none of the comforts so much needed by the sick; quite unable to eat the coarse food at hand, and at night unable to find rest, owing to the swarms of mosquitoes that infest this marshy district of Behar.

The attack on Dewangiri, by General Tombs, was brilliantly successful; the advance up the pass was rapid, and an early hour the following day shewed the troops storming the stockading and forts without a check—nearly 150 Bhooteas were here killed or taken prisoners—and the decisive blows given by the English with such rapidity all along the frontier, struck terror into the enemy, and has led them to come to make terms, suing for peace. But, for the troops, the greatest trial and suffering were yet to come; stationed in the midst of the most unhealthy district, they fell victims to sickness in hundreds; being, in some cases, so utterly decimated and prostrate as to be unable to furnish a single guard. Future travellers in these parts will wonder whose are the rows of graves, who could have been the men to risk the deadly nature of this climate,—a climate that passes as a proverb throughout the country wide. Of those who served in the last of England's little wars, there are but few whose health and constitution have not been broken and impaired. But the price paid would not be grudged by the victims, were it certain that the history thereof taught a lesson or pointed a moral.

DESCRIPTION

OF A

CHRONOGRAPH

ADAPTED FOR MEASURING THE VARYING VELOCITY OF A BODY IN MOTION THROUGH THE AIR, AND FOR OTHER PURPOSES.

BY

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[COMMUNICATED BY THE SECRETARY R.A. INSTITUTION.]

The resistance of fluids to the motion of solids is a problem of great practical and theoretical interest, because sometimes this resistance becomes a source of power, whilst at other times it is a large consumer of power which would otherwise be usefully applied. Thus the action of the wind upon sails is made to drive a mill or a ship. The wind acting upon the sails tends to drive the ship, and the resistance of the water is opposed to the progress of the ship. The resistance of the water to the motion of the oar, the paddle, or the screw, enables the rowers or the steam engine to drive the vessel. A very large part of the power developed in the locomotive is employed in overcoming the resistance of the air to the motion of the train. And quite recently it has been found that the friction of the tidal wave is probably slowly diminishing the velocity of the earth's rotation about its axis. We are dependent upon the resistance of fluids for our power to cross the ocean, for without that property we should not be able to use sail or oar, paddle or screw. Still little is known with accuracy respecting the laws of the resistance of fluids. It is extremely difficult to make satisfactory experiments on account of the great disturbance produced in the surrounding fluid, and as the mathematician knows neither the nature of this disturbance, nor the amount of resistance to be accounted for in particular cases, he is not able to find ground on which to base a satisfactory theory. For a history of what has been done, it will suffice to refer to the articles, "Ballistik" and "Widerstand," in Gehler's Physikalisches Wörterbuch, 1825 and 1842.

The resistance of the air to spherical balls, moving with high velocities, has been a subject of special interest for more than a century, because it was of practical importance to the science of gunnery, and because it offered

a simple yet striking instance of the great resistance which a very rare medium would offer to a solid moving in it with a high velocity. Thus Robins[1] states that Dr Halley thought it reasonable to believe that the opposition of the air to large metal shot is scarcely discernible, although in small and light shot, he acknowledged that it ought and must be accounted for. Robins further states,[2] that a musket-ball, fired with a charge of half its own weight of powder, would leave the gun with a velocity of 1700 f.s., and that, with an elevation of 45°, its range would be 17 miles in a vacuum; whilst practical writers on the subject say that the range in air is short of half a mile. This resistance of the air ρ, depends upon the velocity v, upon the form, and upon the size of the moving body. When a body is at rest in air, the horizontal pressure tending to move it one way is just equal to the pressure tending to move it in the opposite direction. If the body be put in motion by any force, the pressure of the air tending to prevent motion is greater than it was before in that direction, and the pressure in the direction of the motion is less than it was before. The difference of the pressures of the air before and behind the body is called the resistance of the air to that particular form of solid moving with the given velocity: but as the pressure of the air in direction of motion decreases rapidly as the velocity increases, it is commonly neglected.

Thus, ρ is some function of the velocity v, as $f(v)$, such that when the body is at rest, or $v = 0$, we have $\rho = f(v) = 0$. It is usual to assume that ρ can be expanded in a series of the form

$$\rho = av + bv^2 + cv^3 + dv^4 + ev^5 + \&c.$$

where a, b, c, &c. are to be determined by experiment, and are dependent on the form and size of the moving body.

Newton's experiments gave $\rho = bv^2$, and $\therefore a = c = d = \&c. = 0$,

Hutton's gave..... $\rho = av + bv^2$, and $\therefore c = d = \&c. = 0$,

Didion's gave ..... $\rho = bv^2 + cv^3$, and $\therefore a = d = \&c. = 0$,

Colonel Mayevski's gave... $\rho = bv^2 + dv^4$, and $\therefore a = c = \&c. = 0$.

It is possible that the resistance of the air, for a limited range of variation of velocity, may be tolerably represented by one or more of the above formulæ, but we must be careful not to assume that these formulæ must apply to all velocities of the same body, or that the same law will hold for all forms of bodies. Careful experiments must be made so as to discover some empirical law connecting the resistances of the air to bodies of simple forms and the velocities with which they move. When this is well done, all that is needed for practical use will have been obtained. But, beyond this, the mathematician will have been provided with facts which may serve as tests of the soundness of his theoretical investigations, and in the end he may succeed in forming a theory of resistances on mathematical principles, and thus replace our empirical formulæ with one that is true and general.

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[1] Gunnery. Preface, p. 48. [2] p. 145.

Before the discovery of electro-magnetism, the ballistic pendulum of Robins and Hutton afforded the only known practical means for determining the velocities of projectiles and the resistance to their motion exerted by the air. This instrument is so well known that there is no necessity for entering into a minute description of all its parts, and of the precautions to be taken in the use of it. The shot is fired into a body at rest much heavier than itself, to which it communicates motion, so that the two move on together with a common velocity which is capable of being measured. Towards the end of the last century numerous experiments were made with the ballistic pendulum, by Hutton,[1] at Woolwich, with 1, 3, and 6 lbs. spherical balls. Their velocities were measured at distances varying from 30 to 430 feet from the gun. Experiments were also made at Metz with the ballistic pendulum in 1839, &c. with balls of about 8, 12, and 24 lbs.[2] It was found that at 15m. (49 ft.) from the muzzle, the blast from the gun was very sensible. The velocities of the shot were determined at 15, 40, 65, and 90 metres (49, 148, 197, 295 ft.) from the gun. Beyond 295 feet the gun was not sufficiently accurate. Thus the law of the resistance of the air, deduced from the later and more careful experiments, depends upon the loss of velocity of spherical balls moving, at most, through 246 feet. But it is possible to make only one observation on each round. Therefore if it be desired to find the velocity lost by a ball in moving from 15 to 90 metres from the gun, one shot must be fired at the pendulum at a distance of 15 metres, and another at a distance of 90 metres; and, besides the errors in the measurement of the velocities at the moment of impact, there will be a doubt whether the velocity of the second ball, at 15 metres from the gun, was the same as that of the first shot at the same point. The initial velocity therefore enters into the question, and the only thing that can be done in such a case is, to make *numerous* experiments and trust to the *mean* of the results.

Hutton concluded from his experiments that the resistance of the air to a spherical ball $2R$ inches in diameter, was expressed by the formula,[3]

$$\rho = (\cdot 0000073\, v - \cdot 0015)\, v\, (2R)^2.$$

M. Piobert[4] re-calculated the experiments, and deduced the law,

$$\rho = 0{\cdot}030586\ (1 + \cdot 0025\, v)\, v^2 \pi R^2 \text{ in French measures.}$$

Afterwards M. Didion[5] examined them and obtained the law,

$$\rho = 0{\cdot}027\, (1 + \cdot 00257\, v)\, v^2 \pi R^2,$$

and M. Didion[6] gives as his final result, deduced from the Metz experiments,

$$\rho = 0{\cdot}027\, (1 + \cdot 0023\, v)\, v^2 \pi R^2,$$

concluding his "Lois de la Résistance" with the remark on this formula: "Elle peut donc être appliquée avec confiance au tir de tous les projectiles *sphériques* en usage." It is quite plain that Hutton's experiments could not indicate any particular law with great precision since such varied formulæ have been deduced from them.

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[1] Hutton, Tracts, 1812.

[2] Didion, Traité de Balistique, 1848; 2nd Edition, 1861. Lois de la Résistance de l'Air, 1857.

[3] Hutton, Tract 37, p. 229.

[4] Didion, Traité, 1848, p. 44.

[5] Didion, Traité, 1861, p. 64.

[6] Didion, Traité, 1848, p. 52; 1861, p. 66; Lois, 1857, p. 79.

The objections to this mode of experimenting are numerous and self-evident. As the weight of the ball is increased, the vibration and shock caused in the pendulum must give rise to large errors. With the increased distance, there is the difficulty of striking the pendulum so that there may be no impulse on the axis of suspension, and no tendency to twist about a vertical axis. Further, as experiments have been commonly made, the shot were not removed from the receiver until a certain number of rounds had been fired, and thus the positions of the centre of gravity and centre of percussion were in a state of constant variation. There was also the uncertainty arising from the necessity for assuming that the *average* initial velocities were the same for the same charge and ball for different distances of the receiver. The large guns now made cannot be experimented on with the ballistic pendulum in the ordinary way.

I have been particular in referring to dates in what precedes, because M. Didion's *Traité de Balistique* is our standard work on the subject. The theory of the edition of 1861 is practically the same as that of 1848, depending, not only upon the same law of the resistance of the air, but upon the same numerical formula of resistance. The tables to facilitate the practical application of the theory are also, to all intents, the same. We must therefore date this theory 1848, before the Crimean war, and before the introduction of rifled ordnance and projectiles of a cylindrical form. It is true that M. Didion does make some slight reference to small elongated projectiles, diameter 0m.119 (4·7 in.) and length 0m.240 (9·4 in.) for he remarks, "On reviendra, section ix., sur les résistances de divers genres que l'air fait éprouver aux balles oblongues; mais *en attendant que des expériences plus précises aient fourni des résultats plus certains,* nous admettrons pour les balles oblongues pleines et pour les boulets oblongs, un coefficient de résistance égal aux deux tiers de celui de la balle sphérique, c'est-à-dire $A=0{\cdot}081$ et $\rho'=0{\cdot}018\ (1+0{\cdot}0023v)$; il en sera les trois-quarts pour les balles creuses, comme celle du modèle 1859, c'est-à-dire égal à 0·020. On adoptera, pour les boulets oblongs de campagne et de siége, le même coefficient $A=0{\cdot}018$."[1] It is plain, however, that the resistance of the air to elongated shot depends greatly upon the form of the shot, and that something far more precise than the above is required.

It is remarkable that Hutton concluded from his experiments that, for every 100 feet added to the velocity of a shot, there was an increasing addition made to the resistance of the air up to a velocity between 1600 f.s. and 1700 f.s., where it attained a maximum. Thus, in his table of the air's resistance to a ball of 2 inches in diameter, we find[2]

vel. f.s.	Resistance in oz.	Δ_1	Δ_2
1300	683·3		
		+128·2	
1400	811·5		+7·4
		+135·6	
1500	947·1		+4·2
		+139·8	
1600	1086·9		+1·7
		+141·5	
1700	1228·4		−1·3
		+140·2	
1800	1368·6		−3·1
		+137·1	
1900	1505·7		−5·0
		+132·1	
2000	1637·8		

[1] Didion, Traité, p. 74, 1861.

[2] Hutton, Tract 37, p. 218.

This asserted maximum is in itself very improbable, and M. Didion[1] declares that there is none deducible from Hutton's experiments. Hutton's attempt to account for this supposed maximum, by reference to the velocity with which air rushes into a vacuum, is extremely fanciful—because the after-pressure is not great to begin with, it diminishes rapidly as the velocity is increased, but perhaps never entirely vanishes.

Professor Wheatstone applied electricity to measure the velocities of shot in 1840. Afterwards, several changes were made in his instrument. Drawings were shewn in Paris, in May, 1841, and a copy was prepared for Colonel Konstantinoff; but he desired to have an instrument by which he could determine the *velocity of a shot at different points of its path*.[2] M. Breguet afterwards constructed an instrument for this purpose, the performance of which will be further noticed hereafter. This led to a dispute between Professor Wheatstone and M. Breguet, respecting their claims to the invention of the chronograph.[3] Pouillet attempted to determine short intervals of time on the supposition that the deflection of a magnet needle is proportional to the strength of a galvanic current, and to the time it is acted upon by the current. Hipp objected to Professor Wheatstone's arrangement, and made use of a clock going uniformly to measure his time. It does not appear that any of these chronographs have come into use, or that they have given results of any importance.

The electro-ballistic pendulum of Major Navez was invented about 1848, but was brought prominently into notice only in 1855. Very various opinions have been expressed respecting the value of this instrument. The Americans tried it and rejected it on account of the irregularity of its indications. The French used it in 1856, 1857, and 1858, at Metz, to complete their researches on the resistance of the air. "Les résultats n'ont pas été formulés, ils font voir qu'aux vitesses moyennes la valeur de ρ' est égale à celle qui a déjà été donnée, mais que pour des vitesses plus petites la résistance diminuerait *beaucoup plus rapidement* que par la formule déjà obtenue (Art. 52, éq. 7), et qu'elle décroîtrait même trop rapidement pour être dès maintenant admise".[4] Experiments with small arms were continued in 1857 and 1858, with new precautions, on which M. Didion observes: "Elles ont présenté, comme les précédentes, une diminution trop rapide dans les valeurs de ρ', et les résultats *n'ont pas donné une formule qu'on puisse appliquer au tir avec une entière confiance*"[4]. Others who have used the instrument have expressed a very high opinion of its accuracy. It is undoubtedly a great improvement upon all instruments that preceded it for rough practical work, but it is wanting in that precision we are entitled to ask for when electricity is brought to our assistance. It may well be doubted whether anything has been contributed to our knowledge of the laws of the resistance of the air by Major Navez's electro-ballistic pendulum, or by the modifications of it by De Brettes, Vignotti, Leurs, &c. In 1861, it is plain that M. Didion gave the preference to the results of the old ballistic pendulum.

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[1] Didion, Traité, p. 64, 1861.
[2] Müller, Berichte, p. 856, 1848.
[3] Moigno, Traité de télégraphie électrique.
[4] Didion, Traité, 1861, p. 71.

The electro-ballistic pendulum consists of a short pendulum capable of revolving about a horizontal axis through an angle of 75° on each side of the vertical through the point of suspension. As a preparation for the experiment, the bob is raised to its highest position on one side, where it is retained by the attraction of an electro-magnet, whose magnetism is excited by a galvanic current so arranged that, when the shot arrives at the first screen, it breaks the wire through which the galvanic current was passing, and consequently sets the bob free. When the shot reaches a second screen it breaks a second galvanic current, and so destroys the power of a second electro-magnet which had hitherto supported a small weight. This weight now drops, and in its fall *completes* a third galvanic stream which excites a third electro-magnet, and so clamps a light index which had been travelling with the pendulum from its position of rest. The index reading is afterwards taken, and is supposed to give the angle through which the pendulum had moved when the third galvanic stream was closed. An instrument is used from time to time to break simultaneously the first and second galvanic streams, in order to find the time lost by the falling of the weight, by the electro-magnets, &c. One instrument is capable of measuring only *one short* interval of time. The time of describing the various arcs of the instrument are calculated from theory, which neglects friction, temperature, and the resistance of the air, and depends upon the observed time of a mathematically small oscillation of the pendulum. I believe Major Navez directs that not less than 1500 vibrations should be counted. Supposing there are three to the second, this experiment would last 500 seconds, or $8\frac{1}{3}$ minutes, an extremely short time in which to determine the rate of an exact measurer of time. If the 1500 *sufficiently small* vibrations were correctly counted *consecutively*, and if the time was noted by a good chronometer, there would be an error, greater or less, at the beginning and end of the counting. If the vibrations were counted at two or more times, then there would be twice as many small errors. The screens are formed of fine copper wire through which the galvanic currents are made to circulate. The wire is fine in order that it may not obstruct the motion of the ball, and of copper, for the sake of its good conducting power. But copper wire is very liable to stretch before it breaks. Even the wind or the blast accompanying the ball will interfere with the uniformity of its tension. Hence the objections that strike one on looking at such an instrument, are:—

(1) The arrangement of the galvanic streams, varied and complicated.

(2) The determination of the time table not satisfactory.

(3) The wires of the screens are almost certain to be unequally stretched.

(4) The instrument affords no means of checking the accuracy of its indications.

(5) The necessity to employ two or more independent instruments to find the resistance of the air.

Some of these objections might be removed, but the last two appear unavoidable.

Recently a chronographe électro-balistique has been invented by M. P. le Boulengé, Lieutenant d'Artillerie, which has been tried and compared with Major Navez's electro-balistic pendulum, by M. Melsens, Membre de l'Académie Royale de Belgique. He states that M. Boulengé, in his memoir, renders what is just to Major Navez, remarking, "Cet officier en effet a donné, le premier, à l'Artillerie un appareil remplissant toutes les conditions exigées pour être utilement employé aux recherches balistiques; on sait que les essais faits en Angleterre, en France, en Allemagne par des savants illustres, par des militaires distingués, aidés d'ingénieurs et de fabricants habiles, avaient laissé sans solution pratique la question de la détermination des vitesses des projectiles pour tous les cas possibles, tant pour les armes portatives que pour les armes de fort calibre, tirant sous des angles variables."[1] Experiments were made with various powders to compare the two Belgian instruments. The velocity of the same projectile was measured by both instruments for a point 35 metres from the gun. The following list gives the mean velocities in m.s. of five or six rounds for each kind of powder as measured by the two instruments:[2]—

Navez	373·9	376·1	369·6	371·0	367·1	375·1	368·7
Boulengé...	367·9	366·6	368·2	366·8	361·4	369·7	364·9
Difference...	−6·0	−9·5	−1·4	−4·2	−5·7	−5·4	−3·8
Navez	359·1	352·7	369·7	368·2	366·7	351·4	
Boulengé...	355·9	346·0	365·2	364·8	366·7	353·4	
Difference...	−3·2	−6·7	−4·5	−3·4	0·0	+2·0	

Or, converting the differences of the means of the velocities, as determined by the two instruments, into feet-seconds, we find them: −19·7, −31·2, −4·6, −13·8, −18·7, −17·7, −12·5, −10·5, −22·0, −14·8, −11·2, 0·0 and +6·6. M. Melsens appears to give the preference to M. Boulengé's instrument, but he makes the remark, "Des expériences *novelles* et *nombreuses* diront où est la vérité absolue."[3]. Now it is really remarkable that two instruments with any pretensions to accuracy should give such contradictory results. Five or six shot are fired, the velocity in each case is measured by two instruments. The mean of the velocities given by one instrument is compared with the mean of the velocities given by the other, and they differ in one case 31·2 f.s., in another 22·0 f.s., in another 19·7 f.s., and so on. The difference of the *means* varies from −31·2 f.s. to + 6·6 f.s. Thus so long as instruments are used without check, there will always be uncertainties to be settled by new and more numerous experiments. It is the great fault of these instruments that, whilst they are something near the truth, they are not sufficiently exact to give the law of the resistance of the air. But this is the problem that must be solved by any instrument that pretends to accuracy. This must be regarded as the test of the value of any chronograph. Robins was not content merely to determine a list of initial velocities, for he at once proceeded to deduce the resistance of the air to projectiles moving with any

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[1] Melsens, Rapport sur un Chron., 1864. p. 5.
[2] Ibid. Rapport, p. 21.
[3] Melsens, p. 24.

velocity. Hutton did the same. Turn to Didion's Treatise, and there it is found that Chapter I. is devoted to the consideration of projectiles moving in a vacuum, but in Chapter II., when he comes to the consideration of a practical case, he is met by the old difficulty of the *amount* and *law* of the resistance of the air. He also requires to know in what way, and to what extent, the resistance of the air is affected by the *form* and *size* of the moving body. Now it is remarkable that the electro-ballistic pendulum should have been in such general use for more than ten years, and that no satisfactory attempt should have been made to confirm, or otherwise, the laws determined by the old ballistic pendulum for round shot, and to extend them to cylindrical bolts with variously-formed heads. So far as the comparison of the two pendulums is known to have been attempted, we have seen, on the authority of M. Didion, that they give a different law, and that he considers the results of the old ballistic pendulum the more satisfactory of the two. And I am the more inclined to believe that nothing had been attempted with success up to last year from the remarks made by Major Navez in his "*Considérations sur les Expériences de Balistique en ce qui concerne la Mesure du Temps*," 1865. In that tract, he explains in general terms the method to be pursued in order to determine the resistance of the air. He recommends that the screens should be placed as much as 100 metres apart. He finds that M. Boulengé's chronograph cannot measure an interval of time exceeding $0''{\cdot}1$; that of Colonel Leurs cannot exceed $0''{\cdot}227964$. He thinks it would be advantageous to have a superior limit of $0''{\cdot}32$, but contents himself with $0''{\cdot}2$. Major Navez remarks in his introduction: "Nous avons souvent entendu, nous entendons encore chaque jour, des officiers d'artillerie regretter que l'on ne connaisse pas, d'une manière plus précise, la véritable expression de la résistance de l'air quant à sa forme analytique et à sa valeur."[1] And again, "Jusqu'à présent on connaît peu de chose sur la loi de la résistance que l'air oppose aux projectiles allongés; plus tard, lorsque des expériences complètes auront fait découvrir la véritable loi de cette résistance, on trouvera probablement le procédé d'interpolation par arc de cercle bien imparfait. C'est pourquoi nous tenons à établir qu'il s'agit seulement ici d'approximations, grossières peut-être, mais suffisamment approchées de la vérité pour éclairer nos investigations."[2] And the following remark is worthy of particular attention: "Quand on examine en masse les résultats obtenus dans les expériences sur les vitesses conservées par nos projectiles allongés, à différentes distances de tir, on doit se trouver fort satisfait, en ce sens, que de ces résultats ressort, à l'évidence, la bonne conservation de la force vive. *Mais si on se livre à un examen plus minutieux, on voit que ces résultats ne sont pas, en général, assez réguliers pour qu'on puisse les employer à établir la loi de la résistance que l'air oppose aux nouveaux projectiles.*"[3] The perusal of the "Considérations" may be strongly recommended to any one who wishes to understand the true state of the case and the difficulties that have to be overcome. I have always held, and still hold, that as nothing really good has been effected by the ordinary chronographs, so nothing can be done by them. Rather than attempt to

[1] Considérations, p. 4. [2] Ibid. p. 17. [3] Ibid. p. 34.

improve upon old methods, I decided to apply a known method of experimenting which was new to this branch of science.

After a due consideration of all circumstances of the case, it appeared that the following conditions must be satisfied by a chronograph worthy of perfect confidence :—

(1) The time to be measured by a clock going uniformly.

(2) The instrument to be capable of measuring the times occupied by a cannon ball in passing over at least *nine* successive *equal* spaces.

(3) The instrument to be capable of measuring the longest known time of flight of a shot or shell.

(4) Every beat of the clock to be recorded by the *breaking* of the same galvanic current, and under precisely *the same conditions.*

(5) The time of passing each screen to be recorded by the momentary *interruption* of a second galvanic current, and under precisely *the same conditions.*

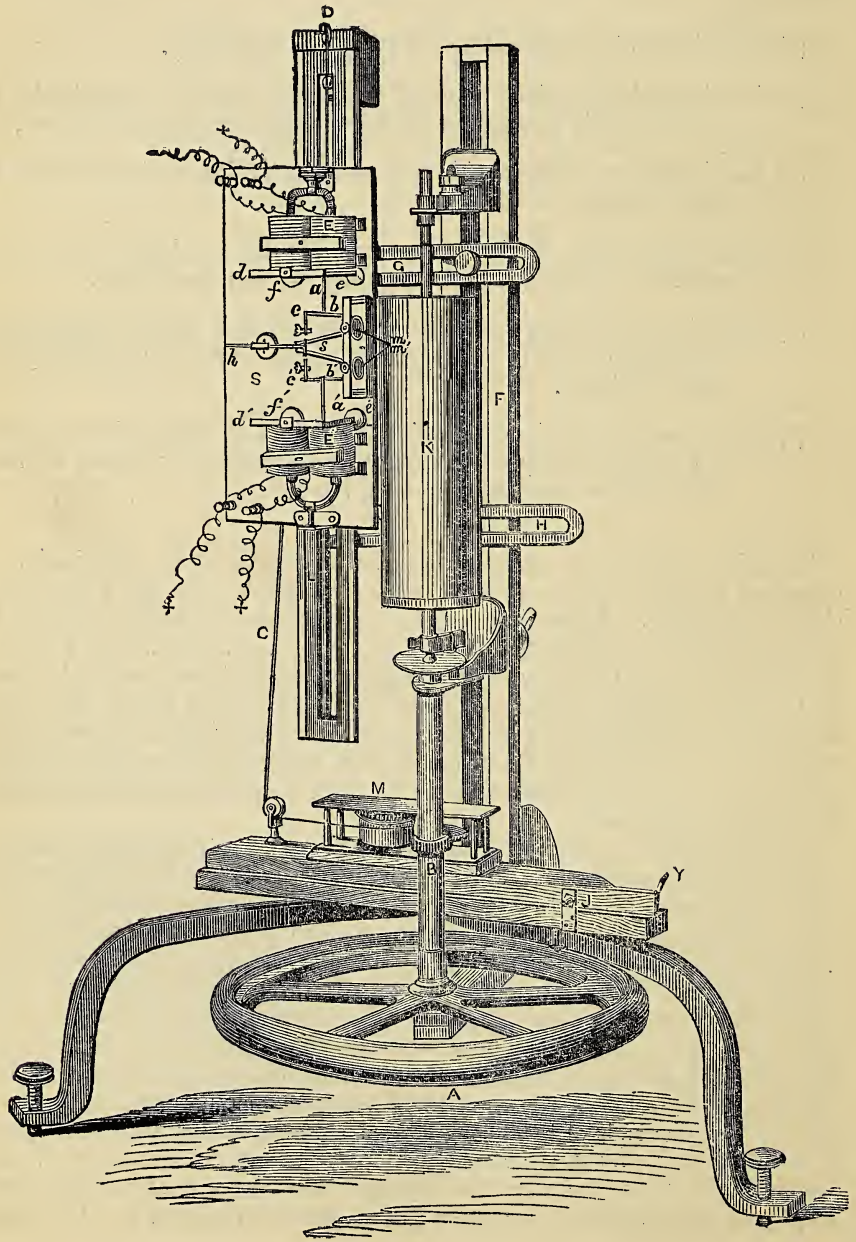
(6) Provision to be made for keeping the strings or wires of the screens in *a uniform state of tension,* notwithstanding the force of the wind and the blast accompanying the ball.

To gain assistance in carrying out the above conditions practically, I consulted a great variety of books on chronographs, electric telegraphs, clock making, &c. A description of one of the most recently constructed chronographs for an Observatory will be found in C. A. F. Peter's *Ueber die Bestimmung des Langen unterschiedes zwischen Altona und Schwerin.* In Loomis's *Practical Astronomy* (New York, 1855), it is stated that this method of recording transits had been employed exclusively at Washington Observatory since 1849, and allusion is made to the conical pendulum then (1855) in use at Greenwich to regulate the velocity of rotation of the cylinder of a similar instrument.

The following is a description of the chronograph as constructed, and of various useful appendages. Fig. 1 gives a general view of the chronograph. *A* is a fly-wheel capable of revolving about a vertical axis, and carrying with it the cylinder *K,* which is covered with prepared paper for the reception of the clock and screen records. The length of the cylinder is 12 or 14 inches, and the diameter 4 inches. *B* is a toothed-wheel which gears with the wheelwork *M* so as to allow the string *CD* to be slowly unwrapped from its drum. The other end of *CD* being attached to the platform *S* allows it to descend slowly along the slide *L,* about $\frac{1}{4}$ inch for each revolution of the cylinder. *E, E'* are electro-magnets; *d, d'* are frames supporting the keepers; and *f, f'* are the ends of the springs which act against the attraction of the electro-magnets. When the current is interrupted in one circuit, as *E,* the magnetism of the electro-magnet is destroyed, the spring *f* carries back the keeper, which by means of the arm *a* gives a blow to the lever *b.* Thus the

marker m is made to depart from the uniform spiral it was describing. When the current is restored the keeper is attracted, and thus the marker m is brought back, which continues to trace its spiral as if nothing had happened. E' is connected with the clock, and its marker m' records the seconds.

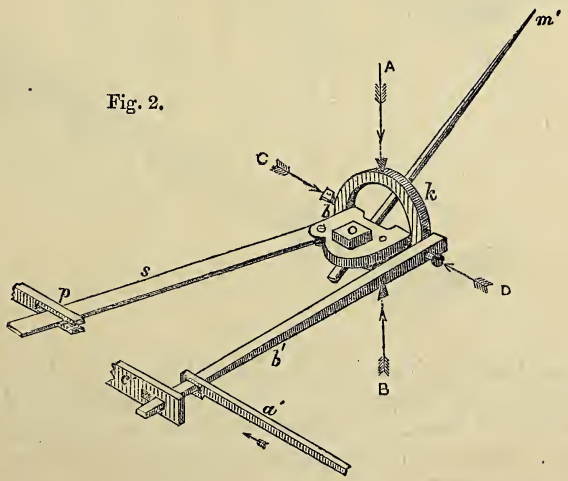
Fig. 1.



E is connected with the screens, and records the passage of the shot through the screens. By comparing the marks made by m, m' the exact velocity of the shot can be calculated at all points of its course. The slide L is fixed parallel to F and the cylinder K by the brackets G, H. Y is a screw for drawing back the wheelwork M, and J a stop to regulate the distance between M and B. The depression of the lever h raises the two springs s, which act as levers, and bring the diamond points m, m' down upon the paper. When an experiment is to be made, care is taken to see that the two currents are complete. The fly-wheel A is set in motion by hand, so as to make about three revolutions in two seconds. The markers m, m' are brought down upon the paper, and after four or five beats of the clock the signal to fire is given, so that in about ten seconds the experiment is completed, and the instrument is ready for another.

Fig. 2 gives a full-sized view of one of the markers, shewing the way in which it is moved. The depression of the lever h (Fig. 1), raises p, and thus the lever s, which is formed of watch-spring wire, brings down m' to the paper, and keeps it gently in contact. This motion takes place within the circle k, about an axis CD. a' is an arm connected with the electro-magnet. When the magnetism in E' is destroyed, a' begins to move away, and when it has moved a short distance it strikes the lever b' a sudden blow which carries it as far as the hole in the stop c' will allow it to move. The The lever b' is rigidly connected with the circle k, which is capable of moving about an axis AB. This motion is communicated to m', which describes a very short arc of a circle about a point in AB. The arrangement is so made that when either of the markers m, m' is making a record, it has a motion which may be resolved partly in direction of the motion of the paper under it, and partly in a direction perpendicular to this. Thus records are obtained which can be read off by scale with great nicety.

Fig. 2.



The pendulum of a half-seconds clock strikes once each double-beat a very light spring, and so interrupts the galvanic current in E' once a second.

Figs. 3 and 4 give the details of the screens. Fig. 3 represents a piece of board 1 inch thick and 6 or 7 inches wide, and rather longer than the width of the screen to be formed. Transverse grooves are cut at equal distances, something less than the diameter of the shot, as shewn in the diagram.

Fig. 3.

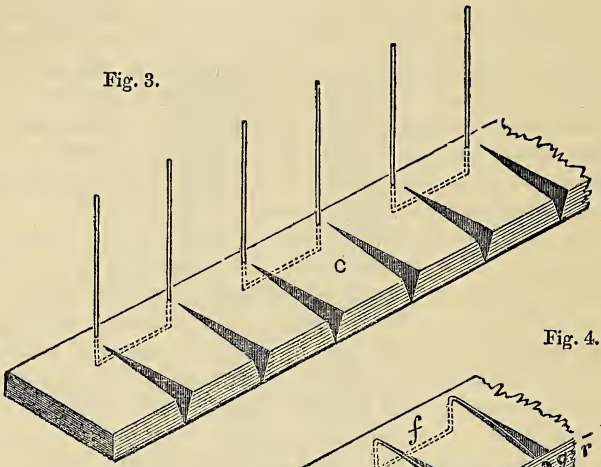
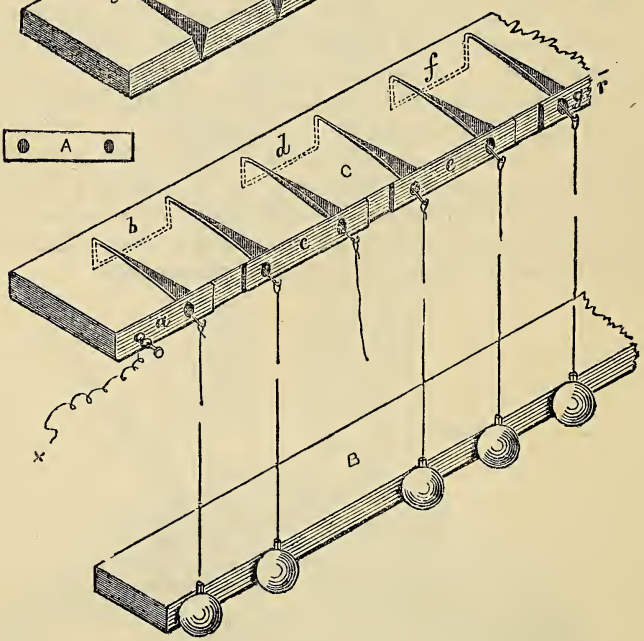


Fig. 4.

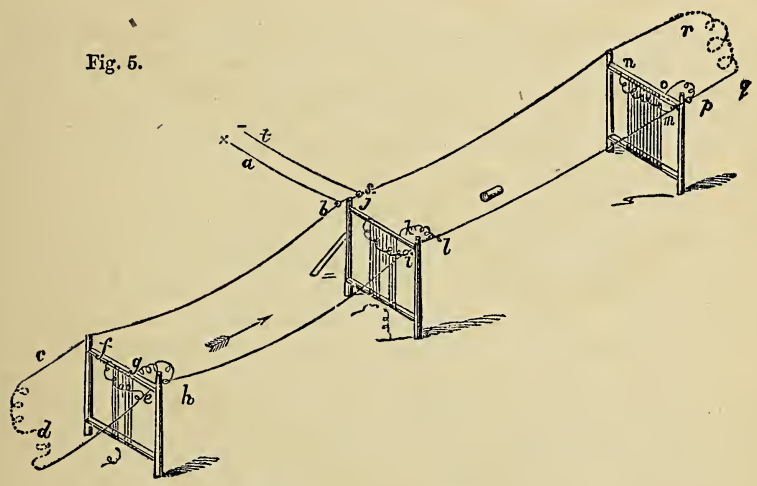


Staples of hard brass spring-wire (No. 14 or 15), are fixed with their prongs in the continuation of the grooves. Pieces of sheet copper *A* are provided, having two elliptical holes, the distance of whose centres equals the distance of the grooves. The pieces of copper *A* are used to connect each wire steeple, as *C*, with its neighbour on each side. Thus, Fig. 4, *a*, *c*, *e*, *g*, &c., represent these copper connections put in their places and holding down the wire spring, which, when free, are in contact with the tops of the holes; but, when properly weighted, they rest on the lower edge of the holes. Thus the

copper *c* forms a connexion between the staples *b* and *d*; the copper *e* joins *d* and *f*, and so on. A galvanic stream will therefore take the following course, whether the springs be weighted or unweighted: copper *a*, brass *b*, copper *c*, brass *d*, copper *e*, brass *f*, copper *g*, &c. The current will only be interrupted when one or more threads have been cut and the corresponding spring is flying from the bottom to the top of its hole. About $\frac{1}{50}$th of a second is required for the complete registration of such an interruption, the spring traversing about half an inch. The shelf *B* is placed for the weights to rest against, partly to prevent them from being carried forward by the shot, but chiefly to prevent the untwisting of the threads which support the weights. The weights used were about 2 lbs. each, and the strength of the sewing cotton for supporting them was equal to a stress of about 3 lbs., which was sufficient to withstand a tolerably strong wind. As the weights were equal the threads were kept equally stretched.

The arrangement of the screens for an experiment is shown in Fig. 5. The wires for conveying the galvanic current are, like the common telegraph wire, carried on posts. *abc* is a continuous piece of wire; but there are interruptions between *e* and *h*, between *i* and *l*, between *m* and *p*, &c., in

Fig. 5.

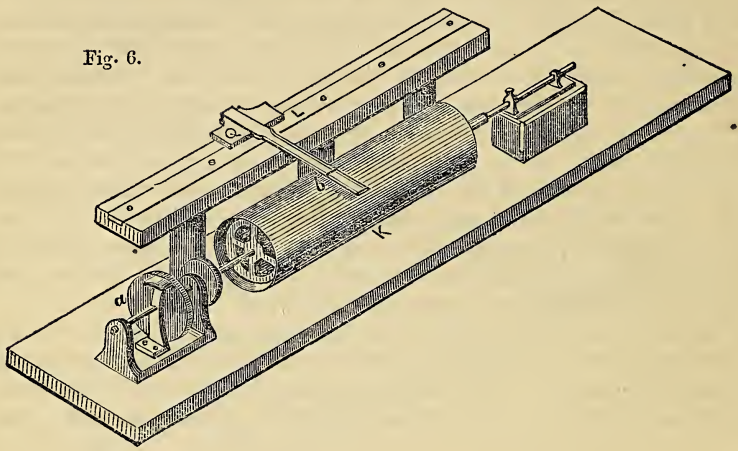


order to make the galvanic current circulate through the screens. The course of the galvanic current is + *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*, *l*, *m*, *n*, *o*, *p*, *q*, *r*, *s*, *t*. The ends *a*, *t*, are connected with the instrument and battery. The shot, being fired through the screens, in passing cuts one or more threads at each screen, so that corresponding to the instant at which the shot passes each screen there is an interruption of the galvanic current, and a simultaneous record on the paper.

When the cylinder is filled with spirals, that is after five or six shots, it is transferred to the instrument, Fig. 6, where *a* is a circle divided into 300 equal parts, and the division is carried to 3000 by the help of a vernier. A small T-square, having a fine edge at *b*, moves along a brass straight-edge *L*, adjusted so as to be parallel to the axis of the cylinder. The mark *b* is

carefully placed opposite each record on the paper by means of a tangent screw (not shewn in the figure), and the vernier is read.

Fig. 6.



The clock goes on breaking the galvanic circuit every swing of the pendulum, whether the marker *m* be in contact with the paper or not—consequently, whatever be the loss of time in the action of the marker, we may fairly suppose it to be constant. But it has been objected that the current having been circulating through the screens for several seconds, or even minutes, without interruption before the shot is fired, the records at the first and the following screens are not made under the *same* conditions. A careful inspection of the results actually obtained shewed that this objection had no foundation to rest upon for that particular experiment; still it seemed desirable to get rid of the objectionable arrangement lest an irregularity might make its appearance in some important experiment. The first screen was placed 120 feet from the gun, the second at 240 feet, and so on. One preparatory break would be obtained by placing a screen at the mouth of the gun; but in addition to this it appears well to introduce the ordinary self-acting contact breaker, made to beat as near as may be the intervals of time to be measured. The raising of a spring lever interrupts the main current of galvanism through the screens. The insertion of a pin to keep up the lever, re-opens a passage for the screen galvanic current through the contact breaker; this may be made also to ring a bell in the instrument room, to give notice that all things are ready for the experiment. The fly-wheel is then put in motion, the signal to fire is given; the pulling of the lanyard withdraws at once the pin, restores the main current, and fires the gun.

The construction of the chronograph was commenced in August, 1864; it was ready for trial in June, 1865. It received its first *partial* trial before the Committee on Gun Cotton in July, 1865, in conjunction with Major Navez's Electro Ballistic Pendulum. The instruments gave a nearly constant difference of 20 f.s. in velocities of about 1500 f.s., and indicated a much greater consistency in the results than in those obtained by M. Melsens when engaged in comparing the two instruments of Major Navez and M.

Boulengé. The chronograph remained at the proof butts from July to November, 1865, when it was taken down to Plumstead Marshes and placed in a splinter-proof, where it remained about a fortnight. Its powers to withstand damp and dust were well tested in this manner. Eighteen shots were fired in all. Two of them were fired by mistake when the cylinder was stationary. One shot carried away a screen, another cut the conducting wire at the second screen, &c. I am able, however, to give a good account of eleven out of the eighteen shots fired on November 23, November 29, and December 12, 1865.

Before proceeding to give an account of the experimental trial of the chronograph, it is necessary to explain at some length the mode of dealing with the clock and screen records, because the absence of any provision to secure uniformity of rotation of the cylinder has appeared to many a great defect. The fact that the variation of velocity of a pendulum, falling from rest through a considerable angle, used in so many instruments, is enormously greater, seems to have been entirely overlooked. The reason for not attempting to secure uniform rotation in the present case was this: the thing has been often attempted, and, so far as I know, never satisfactorily accomplished, when such small intervals of time as the one-hundredth or one-thousandth of a second were of importance. It is sufficient to refer to the chronograph constructed by M. Breguet for Colonel Konstantinoff. M. Gloesener[1] appears to be satisfied with the approach to uniformity of rotation made by that instrument, and gives four experiments in support of his favourable opinion. It will be sufficient to copy the second experiment, which gives the times occupied in making five revolutions in succession:—

2″·05	1″·95	1″·90	1″·80	1″·60	1″·90	1″·90	1″·80
2″·05	2″·00	1″·90	1″·80	1″·90	1″·80	1″·50	2″·30
2″·00	1″·80	1″·80	1″·90	1″·80	1″·60	1″·80	
2″·05	2″·00	1″·80	1″·90	1″·90	1″·80	1″·80	

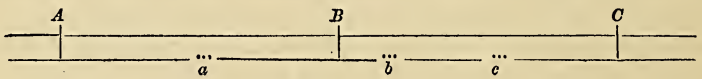
giving a mean time of revolution of 0″·362.

As this result was very far from satisfactory to me, and I had no hope of succeeding so well as M. Breguet, it was quite plain that the difficulty of making the cylinder revolve uniformly must be avoided in the construction of a good chronograph for experiments on gunnery. As already explained, in most, if not in all instruments used in Observatories for recording observations by the aid of electricity, a marker connected with the clock records the seconds. If this were done, it is plain that the length of spiral described in successive seconds would give the rate at which the cylinder was moving. The introduction of a heavy fly-wheel would prevent sudden variations of velocity. The axis was placed in a vertical position, in order to reduce the friction as much as possible, and to avoid errors that might be caused by one side of the fly-wheel being heavier than the other. All unnecessary resistances, all disturbing causes must be removed. It may

[1] Traité général des applications de l'électricité, &c., I. 374.

then be assumed that the cylinder will lose its angular velocity according to some law, which law can be determined from the intervals between five or six successive records of the beats of the clock. The weight of the marking apparatus and electro magnets does, in some measure, act as a driver of the fly-wheel and cylinder, and so tends to keep up the velocity; but it was not introduced for that purpose, and its effect is slight. The *gradual* loss of angular velocity of the cylinder gives a little trouble in the calculation when *extreme* accuracy is desired, but creates not the slightest difficulty to the mathematician. The subject now must be divided into two parts; (1) where a thoroughly trustworthy velocity of a projectile is required, and (2) where the utmost attainable precision is desired, with a view to determine the exact amount and law of the resistance of the air to projectiles of various forms and sizes.

In the first case, the intervals between at least *three* successive beats of the clock should be measured, so as to extend beyond the screen marks on both sides. *Three* screens are the least that can be used with safety, which may be placed 60 or 70 feet apart, or at greater equal distances, if possible. By taking *three* records from the clock, and *three* from the shot, we have a complete check. If the records be found to be consistent, and if *A, B, C,* represent the beats of the clock, and *a* the position of the three screen marks, then the length *AB* must be taken to represent a second, and the



distance from the first to the third mark at *a* would represent, very nearly on the same scale, the time occupied by the shot in passing from the first to the third screen—the use of the middle screen being merely to test the reliability of the screen records. The only calculation is comprised in the proportion—velocity in f:s : distance between first and third screen :: *AB* : distance between first and third record at *a*. If the three screen records fall at *b* near *B*, then $\frac{1}{2}$ (*AC*) must be taken as the representative of a second; or if they fall at *c*, then length of *BC* must be used to represent a second. The velocity so determined would be thoroughly trustworthy, and sufficiently accurate for all practical purposes.

In the second case, where the utmost attainable accuracy is desired, it becomes necessary to have more numerous equidistant screens spread over a greater distance. The screens are placed at *equal* distances because that facilitates calculation, and enables us to judge whether the records are *consistent*. This principle should be carefully observed in all experiments. Thus, if it be required to find how far the initial velocity depends upon the charge of powder, vary the charge by *equal* quantities. If several rounds are to be fired with each particular charge, begin with the highest or lowest, and fire one round of each charge up to the lowest or highest, and so on over again till the experiment be completed. If it be desired to find range tables corresponding to various elevations of the gun, fire one shot at 0°, one at 1°, one at 2°, and so on up to the greatest elevation, and repeat till the experiment is completed. If now the mean range for each degree of elevation be taken, these ranges will follow some kind of law, and after small adjustments have

been made by differencing, the ranges for all intermediate elevations may be found by interpolation. For much valuable information on the mathematical treatment of such subjects, I must refer the reader to three papers by Mr Woolhouse, "On Interpolation, Summation, and the Adjustment of Numerical Tables."[1] He remarks, "If in the direct calculation of a table, the values to be tabulated depend upon a complicated function, difficult of calculation, considerable labour and corresponding risk of error may usually be avoided by computing the values for a *certain succession of equidistant intervals,* and afterwards determining by interpolation all other values that may be requisite to complete the table and adapt it to the practical purposes for which it is constructed. In such case the method is made use of as a powerful *auxiliary* at the option of the computer. If, however, the only available data are *given values* at certain *regular* intervals, and the *mathematical form of the function is unknown,* then the process of interpolation under some of its modifications, becomes *absolutely indispensable,* and its true application is necessarily of great importance where accuracy is required," p. 61. And again, "When a series of quantities which depend upon a *fixed law,* whether *known* or *implied,* follow each other in due order of succession, the general accuracy of their numerical values may be satisfactorily tested by observing the regularity of the progression of a suitable order of differences. If the tabular quantities are the results of calculation from a given formula with *equidistant* arguments, by differencing them up to a certain order, the existence of an isolated error, if one should exist, is thus prominently exhibited, and therefore speedily detected," p. 136. "If, for example, a number of errors, each of which may be of any magnitude, were promiscuously introduced into a page of a table of logarithms, or in any table computed mathematically according to a given formula or generic law which is *still inherent to the general mass of values,* the preceding rules, when applied to the differences would necessarily have the effect of practically eliminating the several errors and restoring the table to its original state of accuracy," p. 142.

The application of the above methods in this particular case is of a very simple kind, because the loss of velocity, both of the fly-wheel and of the shot, goes on very regularly during the short time we are concerned about them. The whole process is shewn applied to Round 1, and the results are given for all the other rounds. The manner of treating the varying velocity of rotation of the cylinder may be illustrated by reference to an ordinary table, say of logarithms. In this case there is not a uniform increase of logarithms corresponding to a uniform increase of numbers, and yet the tables are so arranged and provided with tables of differences, that there is not the slightest difficulty in finding the logarithm of any number, or the number corresponding to any logarithm within the limits of the table.

Suppose that the following logarithms of numbers have been obtained by independent calculation, some of which may be erroneous. They may be tested by taking successive differences, as in (I); then corrected so as to make the column Δ_2 regular, and re-differenced as in (II).

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[1] The Assurance Magazine, Vol. XI. p. 61-68; 301-332; and Vol. XII. p. 136-176.

(I)

Nos.	log	Δ_1	Δ_2	Corrections.
1280	107 210			
		+ 3380		
1290	110 590		− 27	
		+ 3353		
1300	113 943		− 35	+ 10
		+ 3318		
1310	117 261		− 5	− 20
		+ 3313		
1320	120 574		− 35	+ 10
		+ 3278		
1330	123 852		− 24	− 1
		+ 3254		
1340	127 106		− 26	+ 2
		+ 3228		
1350	130 334		− 23	− 1
		+ 3205		
1360	133 539		− 23	
		+ 3182		
1370	136 721			

(II)

log	Δ_1	Δ_2
107 210		
	+ 3380	
110 590		− 27
	+ 3353	
113 943		− 25
	+ 3328	
117 271		− 25
	+ 3303	
120 574		− 25
	+ 3278	
123 852		− 25
	+ 3253	
127 105		− 24
	+ 3229	
130 334		− 24
	+ 3205	
133 539		− 23
	+ 3182	
136 721		

It is at once evident from (I) that a correction of + 10 applied to 117 261, and a correction of −1 applied to 127 106, will introduce regularity into the column of second differences Δ_2. These corrections are introduced in (II), where the differencing has been repeated. We cannot apply the common rule of proportional parts to calculate the logarithms of intermediate numbers, because the column of first differences Δ_1 is so far from being constant. We can, however, find by interpolation the logarithms of 1335, 1345, 1355, &c., thus :—

(III)

Nos.	log	Δ_1	Δ_2
.....			
1330	123 852		
		+ 1629	
5	125 481		− 5
		+ 1624	
1340	127 105		− 7
		+ 1617	
5	128 722		− 5
		+ 1612	
1350	130 334		− 7
		+ 1605	
5	131 939		− 5
		+ 1600	
1360	133 539		− 6
		+ 1594	
5	135 133		− 6
		+ 1588	
1370	136 721		

Still the column of first differences Δ_1 is far from constant, and therefore the rule of proportional parts cannot be applied as (III) now stands. Let the interpolation be carried further, as below :—

(IV)

Nos.	log	Δ_1	Δ_2
.....			
1345	128 722		
		+ 323	
6	129 045		0
		+ 323	
7	129 368		− 1
		+ 322	
8	129 690		0
		+ 322	
9	130 012		0
		+ 322	
1350	130 334		0
		+ 322	
1	130 656		− 1
		+ 321	
2	130 977		0
		+ 321	
3	131 298		0
		+ 321	
4	131 619		− 1
		+ 320	
1355	131 939		

On referring to a table of seven-figure logarithms it will be found that the correct value of log 1351 is 130 6553, whilst the value found above is

130 656, an amount of error to which this method is liable, unless we carry the interpolations one place of figures further. It is on this account that, although the actual measurements of the records on the cylinder of the chronograph do not go beyond the $\frac{1}{1000}$th or $\frac{1}{2000}$th of a second, yet, in interpolation the consideration of $\frac{1}{10},\frac{1}{000}$th or even a smaller part of a second is retained, in order to give greater facilities for the adjustment of column Δ_2 by the application of small corrections, and consequently greater accuracy when the time is expressed in seconds carried to three places of decimals.

The above is an exact representation of the method adopted when the utmost care is required in calculating the time occupied by the projectile in passing from screen to screen. First of all, from some line drawn on the paper parallel to the axis of the cylinder, the clock records are measured and placed in one column; and the screen records are measured and placed in another column. The measurements for the clock should extend over five or six seconds, and overlap the screen records both ways. Both columns are then differenced as in (I). Small corrections are made, where needed, to introduce regularity in the column Δ_2, and the figures are carried one place of decimals further than the measurements. The screen marks thus adjusted are left till a proper time-table has been constructed. By interpolation as in (III), the distance described by the clock tracing point at the end of every half-beat is found. By another interpolation, the space described by the clock marker at the end of every $\frac{1}{10}$th of a beat is found, as in (IV). In all cases it has appeared at this point, that the column of second differences was nothing, or extremely small, so that the rule of proportional parts could be used to determine fractions of a second less than $\frac{1}{10}$th of a second. This completes the time-table. We have now to determine by its help, the times corresponding to the spaces described by the screen tracing point when the first, second, &c. screen was passed: thus, referring to Round 1, we find that

the corrected reading for the sixth screen was.....	41·325
and referring to the time-table we find corresponding to beat 5·4	41·105
	·220

with a difference of 771 corresponding to $\frac{1}{10}$th of a beat. Therefore the sixth screen was passed by the shot at $5{\cdot}4000+\frac{1}{10}\,\frac{220}{771}=5{\cdot}4285$ in beats of the clock.

The necessity for the introduction of small corrections may spring from one or more of the following sources. The reading off from the original records cannot be exactly true. The thread may bend at one screen rather more than at another before breaking. The distance apart of the screens may not be exactly equal. The supporting poles may not be quite vertical. The projectile may strike a thread directly at one screen, at the next it may pass midway between the two threads. Now if some errors be constant throughout the experiment, and if others enter only occasionally into the records, they are of no moment, because the constant errors vanish, and the occassional errors are corrected in the process of differencing. The only errors to be feared are those which follow some law, for if there were such, they would combine with the law of motion of the projectile and so escape detection. But there is little danger of such errors in the use of the chronograph here described, for the records of the clock

and of the screens are made under *precisely the same conditions.* With ten screens, there will be an absolute error, greater or less, in the records of the first and last screen, but whatever be the amount of error in the records of the intermediate screens, there can be no gain or loss of time. If one interval be a little too short, the next will be a little too long, and what is taken from one must be added to the other. The problem is to distribute the small errors between narrow limits. But suppose the nine intervals of time were measured by nine independent instruments, there would be an error, greater or less, at the beginning and end of every interval, making eighteen. And besides this there would be the nine different rates of the measurers of time, and various sources of error peculiar to the construction of so many independent instruments.

Eighteen rounds were fired to test the chronograph. No particular care was taken to examine the form and weight of the shot. The bore of the gun was about 3 inches, and the weight of the projectile about 12 lbs.

ROUND 1, November 23, 1865.

Clock.						Clock.			
Beat.	Reading.	Correction.	Corrected Reading.	Δ_1	Δ_2	Beat.		Δ_1	Δ_2
1	6·880	+ ·001	6·881			3·0	22·509		
				+ 7·828				+ 3·889	
2	14·710	− ·001	14·709		− 28	·5	26·398		− 8
				+ 7·800				+ 3·881	
3	22·510	− ·001	22·509		− 30	4·0	30·279		− 8
				+ 7·770				+ 3·873	
4	30·290	− ·011	30·279		− 31	·5	34·152		− 7
				+ 7·739				+ 3·866	
5	38·020	− ·002	38·018		− 30	5·0	38·018		− 8
				+ 7·709				+ 3·858	
6	45·725	+ ·002	45·727		− 27	·5	41·876		− 7
				+ 7·682				+ 3·851	
7	53·410	− ·001	53·409		− 31	6·0	45·727		
				+ 7·651					
8	61·060	·000	61·060						

Clock.			Screens.					
Beat.	Time Table.	Δ_1	No. of Screen.	Reading.	Correction.	Corrected Reading.	Δ_1	Δ_2
4·5	34·152		1	36·190	−·002	36·188		
		+ ·774					+ 1·007	
·6	34·926		2	* * *	* *	37·195		+10
		+ ·773					+ 1·017	
·7	35·699		3	38·210	+·002	38·212		+11
		+ ·773					+ 1·028	
·8	36·472		4	39·240	·000	39·240		+10
		+ ·773					+ 1·038	
·9	37.245		5	40·280	−·002	40·278		+ 9
		+ ·772					+ 1·047	
5·0	38·018		6	41·330	−·005	41·325		+ 7
		+ ·773					+ 1·054	
·1	38·790		7	42·330	+·049	42·379		+ 6
		+ ·772					+ 1·060	
·2	39·562		8	43·440	−·001	43·439		+ 6
		+ ·772					+ 1·066	
·3	40·334		9	44·500	+·005	44·505		+ 5
		+ ·772					+ 1.071	
·4	41.105		10	45·580	−·004	45·576		
		+ ·771						
5·5	41·876							
		+ ·771						
·6	42·647							
		+ ·771						
·7	43·417							
		+ ·770						
·8	44.187							
		+ ·770						
·9	44·957							
		+ ·770						
6·0	45·727							

By the help of the time-table the corrected screen readings are to be converted into time measured by beats of the clock. As the clock used did not

beat seconds, a further calculation is required in this case to convert beats into seconds. As the period from which we measure time is quite arbitrary—if we subtract the time of passing the first screen from the times of passing the other screens, we obtain a table giving the time occupied by the shot in passing from the first to any succeeding screen. The whole must be differenced as a test of the accuracy of the work, and any necessary correction must be introduced. The first column of differences (Δ_1) represents the time of passing from screen to screen. If the clock used, as is intended, beat seconds, and if it be found that during the course of any set of experiments it does not keep exact time, but gains or loses 1 in 1000, say, then the times last found will require to be diminished or increased 1 in 1000. A small correction of this kind was required, differing slightly in Rounds 1-9 and 10-18. If the clock had been perfectly adjusted, the length of a beat would have been 0·″81586.

No. of Screen.	Corrected Screen Reading.	Beats of Clock.	Beats of Clock.	Seconds.	Δ_1	Δ_2
				″		
1	36·188	4·7633	0·0000	0·0000		
					+ 1064	
2	37·195	4·8935	0·1302	0·1064		+13
					+ 1077	
3	38·212	5·0252	0·2619	0·2141		+11
					+ 1088	
4	39·240	5·1583	0·3950	0·3229		+11
					+ 1099	
5	40·278	5·2927	0·5294	0·4328		+10
					+ 1109	
6	41·325	5·4284	0·6651	0·5437		+10
					+ 1119	
7	42·379	5·5652	0·8019	0·6556		+ 7
					+ 1126	
8	43·439	5·7029	0·9396	0·7682		+ 6
					+ 1132	
9	44·505	5.8413	1·0780	0·8814		+ 4
					+ 1136	
10	45·576	5·9804	1·2171	0·9950		

For the remaining 10 rounds it will be sufficient to give the clock and screen readings and their corrections.

ROUND 2.

Clock.			Screens.					
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading.	Time.	Δ_1	Δ_2
							″		
5·030	·000	5·030	1	32·993	— ·001	32·992	0·0000		
								+1045	
10·700	+ ·005	10·705	2	* * *	*	33·713	·1045		+ 8
								+1053	
16·370	+ ·001	16·371	3	34·435	+ ·004	34·439	·2098		+ 9
								+1062	
22·030	— ·002	22·028	4	35·175	— ·004	35·171	·3160		+10
								+1072	
27·680	— ·003	27·677	5	35·905	+ ·005	35·910	·4232		+15
								+1087	
33·320	·000	33·320	6	36·665	— ·005	36·660	·5319		+16
								+1103	
38·950	+ ·007	38·957	7	37·425	— ·005	37·420	·6422		+13
								+1116	
44·590	·000	44·590	8	38·190	·000	38·190	·7538		+16
								+1132	
			9	38·970	·000	38·970	·8670		+16
								+1148	
			10	39·760	·000	39·760	·9818		

ROUND 5.

Clock.			Screens.						
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading.	Time.	Δ_1	Δ_2
							"		
20·860	− ·004	20·856	1	26·190	− ·003	26·187	0·0000		
36·370	+ ·004	36·374	2	* * *	*	28·171	·1046	+1046	
51·850	·000	51·850	3	30·170	+ ·006	30·176	·2102	+1056	+10
67·280	·000	67·280	4	32·210	− ·008	32·202	·3170	+1068	+12
			5	34·250	− ·002	34·248	·4248	+1078	+10
			6	36·290	+ ·023	36·313	·5338	+1090	+12
			7	38·400	000	38·400	·6438	+1100	+10
			8	40·510	+ ·002	40·512	·7553	+1115	+15
			9	42·650	000	42·650	·8682	+1129	+14
			10	* * *	*	* * *			

ROUND 7, November 29, 1865.

Clock.			Screens.						
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading.	Time.	Δ_1	Δ_2
							"		
35·850	+ ·004	35·854	1	65·860	− ·006	65·854	0·0000		
53·560	·000	53·560	2	68·100	− ·007	68·093	·1033	+1033	
71·200	+ ·009	71·209	3	70·360	+ ·007	70·367	·2087	+1054	+21
88·830	− ·015	88·815	4	72·670	+ ·004	72·674	·3157	+1070	+16
106·380	+ ·009	106·389	5	* * *	*	75·007	·4240	+1083	+13
			6	77·360	·000	77·360	·5333	+1093	+10
			7	79·720	+ ·009	79·729	·6433	+1100	+ 7
			8	82·110	+ ·006	82·116	·7541	+1108	+ 8
			9	84·530	− ·007	84·523	·8659	+1118	+10
			10	86·950	·000	86·950	·9787	+1128	+10

ROUND 10, December 12, 1865.

Clock.			Screens.						
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading.	Time.	Δ_1	Δ_2
							"		
18·140	− ·002	18·138	1	38·960	+ ·002	38·962	0·0000		
26·290	+ ·005	26·295	2	40·000	− ·002	39·998	·1054	+1054	
34·400	− ·009	34·391	3	41·040	+ ·001	41·041	·2117	+1063	+ 9
42·430	− ·003	42·427	4	* * *	*	42·092	·3189	+1072	+ 9
50·400	+ ·006	50·406	5	* * *	*	43·154	·4273	+1084	+12
58·320	+ ·011	58·331	6	44·240	− ·014	44·226	·5368	+1095	+11
			7	45·310	·000	45·310	·6477	+1109	+14
			8	46·410	− ·005	46·405	·7600	+1123	+14
			9	* * *	*	47·513	·8736	+1136	+13
			10	48·640	− ·005	48·635	·9884	+1148	+12

ROUND 11.

Clock.			Screens.						
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading.	Time.	Δ_1	Δ_2
							"		
9·010	·000	9·010	1	53·710	+ ·006	53·716	0·0000		
21·440	+ ·002	21·442	2	55·290	− ·006	55·284	·1047	+1047	
33·820	− ·004	33·816	3	56·870	+ ·004	56·874	·2110	+1063	+16
46·130	·000	46·130	4	58·490	− ·004	58·486	·3188	+1078	+15
58·390	− ·008	58·382	5	60·120	·000	60·120	·4281	+1093	+15
70·570	+ ·002	70·572	6	61·770	+ ·002	61·772	·5387	+1106	+13
82·710	− ·010	82·700	7	* * *	*	63·440	·6505	+1118	+12
			8	65·120	·000	65·120	·7630	+1125	+ 7

ROUND 13.

Clock.			Screens.						
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading.	Time. "	Δ_1	Δ_2
0·200	— ·010	0·190	1	30·780	+ ·004	30·784	0·0000		
9·880	+ ·001	9·881	2	32·020	— ·002	32·018	·1051	+1051	
19·540	— ·002	19·538	3	33·260	+ ·004	33·264	·2112	+1061	+10
29·170	— ·008	29·162	4	34·520	+ ·001	34·521	·3183	+1071	+10
38·750	+ ·006	38·756	5	35·790	+ ·002	35·792	·4266	+1083	+12
48·320	+ ·003	48·323	6	37·080	— ·002	37·078	·5362	+1096	+13
57·870	— ·004	57·866	7	38·380	— ·002	38.378	·6471	+1109	+13
			8	39·690	+ ·001	39·691	·7592	+1121	+12
			9	41·010	+ ·007	41·017	·8723	+1131	+10
			10	42·360	— ·005	42·355	·9866	+1143	+12

ROUND 15.

Clock.			Screens.						
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading.	Time. "	Δ_1	Δ_2
3·100	— ·004	3·096	1	61·220	— ·002	61·218	0·0000		
15·330	— ·002	15·328	2	62·760	+ ·001	62·761	·1042	+1042	
27·520	+ ·007	27·527	2	64·320	+ ·008	64·328	·2102	+1060	+18
39·690	+ ·003	39·693	4	65·920	— ·004	65·916	·3175	+1073	+13
51·830	— ·003	51·827	5	67·520	+ ·002	67·522	·4262	+1087	+14
63·930	+ ·002	63·932	6	69·150	— ·006	69·144	·5359	+1097	+10
76·010	·000	76·010	7	70·770	+ ·009	70·779	·6466	+1107	+10
			8	72·430	— ·005	72·425	·7580	+1114	+ 7

ROUND 16.

Clock.			Screens.						
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading.	Time. "	Δ_1	Δ_2
2·720	·000	2·720	1	52·460	·000	52·460	0·0000		
18·010	·000	18·010	2	54·410	— ·003	54·407	·1050	+1050	
33·260	— ·005	33·255	3	55·970	+ ·406	56·376	·2111	+1061	+11
48·450	+ ·007	48·457	4	58·370	— ·001	58·369	·3185	+1074	+13
63·620	— ·002	63·618	5	60·380	+ ·006	60·386	·4273	+1088	+14
78·740	·000	78·740	6	62·420	+ ·007	62·427	·5375	+1102	+14
			7	64·500	— ·008	64·492	·6490	+1115	+13
			8	* * *	*	66·580	·7617	+1127	+12
			9	68.690	·000	68·690	·8757	+1140	+13
			10	70·820	·000	70·820	·9908	+1151	+11

ROUND 17.

Clock.			Screens.						
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading.	Time. "	Δ_1	Δ_2
10·830	+ ·008	10·838	1	55·370	— ·002	55·368	0·0000		
23·100	— ·008	23·092	2	56·930	+ ·002	56·932	·1049	+1049	
35·320	+ ·008	35·328	3	58·520	·000	58·520	·2114	+1065	+16
47·540	+ ·004	47·544	4	60·140	— ·011	60·129	·3193	+1079	+14
59·750	— ·009	59·741	5	61·760	— ·004	61·756	·4285	+1092	+13
71·910	+ ·008	71·918	6	63·440	— ·038	63·402	·5389	+1104	+12
84·070	+ ·003	84·073	7	65·060	+ ·006	65·066	·6505	+1116	+12
			8	* * *	*	66·751	·7636	+1131	+15
			9	68·460	— ·001	68·459	·8783	+1147	+16
			10	70·190	+ ·003	70·193	·9947	+1164	+17

ROUND 18.

Clock.			Screens.						
Reading.	Correction.	Corrected Reading.	No.	Reading.	Correction.	Corrected Reading	Time.	Δ_1	Δ_2
							″		
46·350	·000	46·350	1	57·270	+ ·001	57·271	0·0000		
54·790	+ ·010	54·800	2	58·360	+ ·003	58·363	·1057	+1057	+ 9
63·260	— ·010	63·250	3	59·470	— ·004	59·466	·2123	+1066	+11
71·700	·000	71·700	4	60·580	— ·001	60·579	·3200	+1077	+10
			5	61·700	+ ·003	61·703	·4287	+1087	+11
			6	62·840	— ·002	62·838	·5385	+1098	+12
			7	63·980	+ ·005	63·985	·6495	+1110	+13
			8	* * *	*	65·146	·7618	+1123	+13
			9	66·320	+ ·001	66·321	·8754	+1136	+15
			10	67·510	— ·001	67·509	·9905	+1151	

As these experiments were made merely to test the instrument, the forms and weights of the shot were not examined, consequently nothing would be gained by attempting to find the law of resistance in each of the preceding cases. This method of proceeding, or something equivalent, will be necessary when that law is sought for, because the shot do not pass the first screen with the *same* velocity. At present it will be sufficient to find the mean time occupied by the ball in passing from the first to each of the following screens. We are thus able to answer, *from experiment alone,* the practical question, what is the *average* velocity of a 12 lb. shot fired from the given gun with the given charge, at any point between 120 feet and 1000 feet from the gun?

Round	Screen 1	Screen 2	Screen 3	Screen 4	Screen 5	Screen 6	Screen 7	Screen 8	Screen 9	Screen 10
	″	″	″	″	″	″	″	″	″	″
1	0·0000	0·1064	0·2141	0·3229	0·4328	0·5437	0·6556	0·7682	0·8814	0·9950
2	·0000	·1045	·2098	·3160	·4232	·5319	·6422	·7538	·8670	·9818
5	·0000	·1046	·2102	·3170	·4248	·5338	·6438	·7553	·8682	*
7	·0000	·1033	·2087	·3157	·4240	·5333	·6433	·7541	·8659	·9787
10	·0000	·1054	·2117	·3189	·4273	·5368	·6477	·7600	·8736	·9884
11	·0000	·1047	·2110	·3188	·4281	·5387	·6505	·7630	*	*
13	·0000	·1051	.2112	·3183	·4266	·5362	·6471	·7592	·8723	·9866
15	·0000	·1042	.2102	·3175	·4262	·5359	·6466	·7580	*	*
16	·0000	·1050	·2111	·3185	·4273	·5375	·6490	·7617	·8757	·9908
17	·0000	·1049	·2114	·3193	·4285	·5389	·6505	·7636	·8783	·9947
18	·0000	·1057	·2123	·3200	·4287	·5385	·6495	·7618	·8754	·9905
Totals ...	·0000	1·1538	2·3217	3·5029	4·6975	5·9052	7·1258	8·3587	7·8578	7·9065
Divisors	...	11	11	11	11	11	11	11	9	8
Means...	·00000	·10489	·21106	·31845	·42705	·53684	·64780	·75988	·87309	·98831

Distance from gun.	Screen.	Average Time.	Δ_1	Δ_2
ft.		″		
120	1	0·00000		
240	2	·10489	+ 10489	
360	3	·21106	+ 10617	+ 128
480	4	·31845	+ 10739	+ 122
600	5	·42705	+ 10860	+ 121
720	6	·53684	+ 10979	+ 119
840	7	·64780	+ 11096	+ 117
960	8	·75988	+ 11208	+ 112
1080	9	·87309	+ 11321	+ 113
1200	10	·98831	+ 11522	+ 201

The irregularity at the 9th and 10th screens is caused by the failure of a few screens in rounds 5, 11, and 15. We can now, by means of a common interpolation formula calculate the average time occupied by the shot in moving over 20 feet, or $\frac{1}{6}$ of 120 feet, from each screen. And dividing 20 by this fraction of a second, we obtain the velocity of the shot at 130, 250, 370, &c. feet from the gun.

Distance from gun. ft.	Velocity. f.s.	Δ_1	Δ_2
130	1149·4		
		−13·7	
250	1135·7		+ ·6
		−13·1	
370	1122·6		+ ·4
		−12·7	
490	1109·9		+ ·5
		−12·2	
610	1097·7		+ ·6
		−11·6	
730	1086·1		+ ·5
		−11·1	
850	1075·0		+ ·4
		−10·7	
970	1064·3		

By interpolation we are now able to obtain from experiment *alone* the average velocity of the eleven shot at every ten feet from the gun, from 130 to 1000 feet. The result is

Distance from gun.	Velocity. f.s.	Distance from gun.	Velocity. f.s.	Distance from gun.	Velocity. f.s.	Distance from gun.	Velocity. f.s.
ft.		ft.		ft.		ft.	
130	1149·4	360	1123·6	590	1099·7	820	1077·7
140	1148·2	370	1122·6	600	1098·7	830	1076·8
150	1147·1	380	1121·5	610	1097·7	840	1075·9
160	1145·9	390	1120·4	620	1096·8	850	1075·0
170	1144·8	400	1119·4	630	1095·8	860	1074·1
180	1143·6	410	1118·3	640	1094·8	870	1073·2
190	1142·5	420	1117·2	650	1093·8	880	1072·3
200	1141·3	430	1116·2	660	1092·9	890	1071·4
210	1140·2	440	1115·1	670	1091·9	900	1070·5
220	1139·0	450	1114·1	680	1090·9	910	1069·6
230	1137·9	460	1113·0	690	1089·9	920	1068·7
240	1136·8	470	1112·0	700	1089·0	930	1067·8
250	1135·7	480	1110·9	710	1088·0	840	1066·9
260	1134·6	490	1109·9	720	1087·1	950	1066·1
270	1133·5	500	1108·8	730	1086·1	960	1065·2
280	1132·4	510	1107·8	740	1085·2	970	1064·3
290	1131·3	520	1106·8	750	1084·3	980	1063·4
300	1130·2	530	1105·8	760	1083·3	990	1062·6
310	1129·1	540	1104·7	770	1082·4	1000	1061·7
320	1128·0	550	1103·7	780	1081·5		
330	1126·9	560	1102·7	790	1080·5		
340	1125·8	570	1101·7	800	1079·6		
350	1124·7	580	1100·7	810	1078·7		

Supposing that the average times occupied by the shot in travelling from the first to each succeeding screen were expressed in seconds carried to only three places of decimals, the second differences of the time would be nearly constant. If they were exactly constant, then the time t occupied by the shot in passing from the first screen to a point s feet from it, would be

connected with s by an equation of the form $t=as+bs^2$. This would give the velocity v at that point $=(a+2bs)^{-1}$, and a retarding force varying as v^3.

If the average values of s and t, determined by experiment at the 4th and 8th screens, be used to find a and b, we have

$$\cdot 31845 = a \times 360 + b \times (360)^2,$$

$$\cdot 75988 = a \times 840 + b \times (840)^2,$$

which two equations give $a = \cdot 000,\ 869,\ 558,$

$$b = \cdot 000,\ 000,\ 0417,$$

and $\therefore\ t = \cdot 000,\ 869,\ 558\, s + \cdot 000,\ 000,\ 0417\, s^2,$

$$v = \frac{1000}{\cdot 869,\ 558,\ + \cdot 000,\ 0834 s}.$$

Or if we measure the distance s' from the gun we have $s'=s+120$ or $s=s'-120$,

$$v = \frac{1000}{\cdot 869,\ 588 + \cdot 000,0834\,(s' - 120)}$$

$$= \frac{1000}{\cdot 859,\ 550 + \cdot 000,\ 0834 s'},$$

and giving s' the particular values 0, 100, 200, &c., we find the velocities of the shot at 0, 100, 200, &c. feet from the gun by the formula, which we may compare with those derived purely from experiment by interpolation, as given above

Distance from gun.	Velocity by Formula.	Difference.	Velocity by Experiment.
ft.	f.s.	f.s.	f.s.
0	1163·4	*	* * *
100	1152·2	*	* * *
200	1141·3	0·0	1141·3
300	1130·5	− 0·3	1130·2
400	1119·9	− 0·5	1119·4
500	1109·6	− 0·8	1108·8
600	1099·4	− 0·7	1098·7
700	1089·4	− 0·4	1089·0
800	1079·6	0·0	1079·6
900	1070·0	+ 0·5	1070·5
1000	1060·5	+ 1·2	1061·7

It is evident that this table requires to be extended both ways, so as to give the law for higher and lower velocities. Thus initial velocities of 1200 f.s. or more, and lower velocities of 1100, 1050, 1000 f.s., &c., are required. In all these cases it must be remembered that our velocity is the horizontal velocity $\frac{dx}{dt}$ or v_1 of M. Didion.

To obtain a satisfactory table shewing the velocity of a given ball projected with the highest possible velocity, at all distances from the gun, I am satisfied that four good shots through ten screens with each particular charge would be amply sufficient. The shot should have exactly the same form of head,

and be of precisely the same weight. One shot should be fired with a velocity 1200 f.s., then one with 1150 f.s., then one 1100 f.s., so far as the height of the screens would allow. The same series must be gone through three times more. In the subsequent treatment of a complete and standard experiment of this kind, it is evident that instead of measuring the time from the instant of passage of the first screen, it will be necessary to measure the time in each round of four, from the instant when each shot had a certain velocity.

A few hollow shot of the same external form might be fired with advantage. For low velocities it would be advisable to remove three or four of the middle screens.

A good test of the truth of the law deduced from experiments with various initial velocities would be obtained by firing a few rounds with the highest initial velocity through three screens near the gun, and three at a distance of 4500 or 6000 feet. The chronograph would give initial and final velocities and the time of flight. It would be advisable to try the experiments on the long range when the wind was blowing directly with and directly against the shot, also when the wind was blowing at right angles to the direction of the line of fire. Also the effect of the height of the barometer, and of the degree of moisture, on the resistance of the air might best be determined by a few shots on the long range when the air was perfectly still.

In the experiments just suggested, the law of initial velocity, so far as it depends upon the charge, would be determined with great precision. The results might also be treated in two ways, that is, so as to obtain both an average velocity at any distance from the gun, and the true law of the resistance of the air.

If *similar* forms of shot were used in experiments of the above kind, with bores of 3, 5, 7, 9, 11, and 13 inches, we should be able to extend, by interpolation, the laws obtained from these experiments for the above particular cases to all possible calibres from 3 to 13 inches. It would be an easy matter to bring all needful experiments of the above nature to a satisfactory conclusion within six months. When this work was once well done there could be no pretence for ever re-opening the question. Take, for instance, the table of velocities which has been given for one particular calibre and form of head. What more information can be required for the same gun and projectile after that table has been extended both ways with the same exactness, to the highest and lowest practical limits? The force of the charge of powder, taking account of quality and quantity, must be known in any practical case. Suppose that the initial velocity for a smaller charge, or a different powder, was 1120 f.s., and that it was required to find the velocity at a point 500 feet from the gun. Referring to the table, we find the velocity at 394 feet from the gun was 1120 f.s., and 500 feet farther on, or at 394 + 500 = 894 feet in the table, the velocity was 1071 f.s. So that a shot starting with an initial velocity of 1120 f.s. would have a velocity 1071 f.s. after it had travelled 500 feet through the air. All this information is derived purely from experiment, and is therefore free from any question as to the value of a formula or a theory. For a hollow shot, of the same external form as the solid shot used in the experiment, the air would exert precisely the same resistance for a given velocity; but its effect

would be more sensible from the diminished mass of the body it acted upon. For a slight increase of length in the cylindrical part of a shot there is but a very slight increase of the resistance of the air.

Having determined the law of variation of the velocity of a cannon ball moving through the air, there remains the scarcely less important problem to find according to what law the velocity is communicated to the shot inside the bore of the gun by the action of the gas of the exploding powder. The solution of this problem will shew how the work is distributed inside the gun, and consequently the amount of stress upon the gun corresponding to any position of the shot, for a given quality and weight of powder. If one powder exploded more suddenly and completely than another, and if the weight of the charges were so adjusted as to give the same velocity when the shot leaves the gun; although the total work done would be the same, the law of distribution of the work would be very different in the two cases. The rapidly exploding powder would give a high initial pressure upon the ball, which would decrease rapidly as the ball moved, and become less towards the muzzle than that arising from the explosion of a slowly burning powder. The former would therefore be a more severe trial of the gun than the latter, although the same velocity of the ball would be obtained in the two cases. If powder could be manufactured and fired so as to keep up a *constant* pressure upon the ball from one end of the bore to the other, in such a case a given velocity would be obtained with the least possible strain upon the gun. The introduction of rifled ordnance has rendered the degree of rapidity of the explosion of powder a question of greater importance than it was when smooth bores only were used; for the effect of rifling must be to hinder the forward motion of the ball at the first, and consequently to increase the initial strain on the gun. The increasing spiral groove is therefore a great improvement on the uniform spiral; its form ought to be such as to give equal additions to the angular velocity of the shot in equal *times*, not in equal *spaces*. Consequently, as the velocity of translation of a shot depends upon the nature of the powder, the weight of the charge, and the weight of the ball, a change in any one of these would, in strictness, call for a different kind of rifling. But probably great nicety is not required, provided the twist is small at the bottom of the bore, and that it increases gradually up to such an angle at the muzzle as is required to give steadiness to the shot. The angular velocity necessary to give the requisite steadiness to shot of various lengths and calibres requires careful experimental treatment, because we do not know theoretically the exact forces which act upon the projectile.

The common formula for initial velocity is built upon the assumptions—

(1) That all the powder is converted into gas before the ball moves sensibly.

(2) That the pressure of the gas afterwards always varies as its density.

If these assumptions were true, it would not matter what air space was left between the powder and ball, or what was the number of shot put into the gun. For a given space occupied by the gas there could only be one

pressure, and the only effect of either of the above experiments would be to increase the time during which that pressure acted. Experiments have shewn that the initial velocity of a shot will depend upon the point at which the charge is ignited, all other things remaining the same. And Daniel Bernouilli, who gave the common formula for the calculation of initial velocity in 1738, at that time expressed his belief that the whole charge was not fired instantaneously, and more than a century ago a Committee of the Royal Society, appointed to examine this question, came to the conclusion that the whole of the powder is *not* fired before the ball is sensibly moved from its place. Why then are we to retain a mathematical formula which is manifestly based on an erroneous assumption? The thorough contradiction between the results of this formula and of the experiments with the 70-pr. Armstrong and Whitworth guns with charges of 10 lbs., ought to be the death blow to the formula. The length of bore of the Armstrong muzzle-loader was 10 feet 3·25 inches, and length of cartridge, 12·81 inches. The ratio of weight of powder to weight of ball was ·1403; and the initial velocity was 1336 f.s. Substituting these values in the formula

$$V = \sqrt{\gamma \frac{\mu}{m + \frac{1}{3}\mu} \log \frac{M}{\mu}},$$

$$1836 = \sqrt{\gamma}\sqrt{\frac{\cdot 1403}{1 + \frac{1}{3} \times \cdot 1403} \log \frac{123 \cdot 25}{12 \cdot 81}}, \text{ which gives } \sqrt{\gamma} = 3680 \cdot 3.$$

As the powder was the same in quality in the two cases $\sqrt{\gamma}$ is a constant. Now apply the formula to calculate the initial velocity for the Whitworth gun, the bore of which was 9 feet 11 inches = 119 inches long. The length of cartridge was 14·5 inches, and the ratio of weight of powder to weight of shot was ·1427. We find by the formula the initial velocity

$$= 3680 \cdot 3 \times \sqrt{\frac{\cdot 1427}{1 + \frac{1}{3} \times \cdot 1427} \log \frac{119}{14 \cdot 5}} = 1298 \cdot 7 \text{ f.s.},$$

whilst the velocity found by experiment was 1338 f.s. Thus the formula gives for the Whitworth gun a velocity *decidedly less* than that for the Armstrong, whereas experiment gives a velocity *slightly greater*. The formula gives 1298·7 feet as the velocity at the gun, whereas experiment shews that this would be the velocity at a point about 600 feet from the gun.

Under these circumstances it is quite plain that this formula is perfectly useless in determining the stress upon the gun. Captain Rodman used his pressure gauge in very numerous experiments, but as might have been expected from the shortness of the time during which the pressures were applied, the instrument did not give results sufficiently regular. Major Navez has proposed to use his pendulum to measure the times occupied by the shot in traversing different parts of the bore of the gun, but inasmuch as these intervals of time must be very short, and as every measurement must depend upon the action of three electro-magnets, it may very naturally be doubted whether the results would be of any value. The only method which appears to me to hold out any prospect of success, is one to which Captain Rodman gave a very partial trial. He mounted a gun in the old gun pendulum. A cylinder was placed with its axis parallel to the bore of

the gun. When the gun recoiled it drew back a tracing point which marked a straight line on the surface of the cylinder at rest. If, whilst the gun was stationary, the cylinder was made to rotate, the tracing point described a circle on the surface of the cylinder. If now the cylinder be made to rotate rapidly, and left to itself, and if the gun be fired, the point will trace out a curve on the surface of the cylinder, the ordinate of which will represent the time occupied by the gun in recoiling through a space equal to the abscissa. The *law* of the work done to produce the recoil thus becomes known. By measuring the initial velocity of the shot, the total amount of the work done by the powder is found. The law of the pressure of the gas would be found with greater exactness if the tracing point was connected with the projectile. This method of experimenting seems to be the only one likely to give a satisfactory result, for if the rotation of the cylinder be uniform for the very short time the explosion is in progress, there can be no doubt that the co-ordinates of the diagram would give us a connexion between the time and space, and knowing the weight and velocity of the moving body at any one point, we can tell the amount of pressure that was acting upon it at any instant, or for any position. From what has been said, it is evidently of great importance in the proof of gunpowder, that besides the trial for initial velocity, there should be some test of the stress thrown on the gun.

The law of penetration of iron plates by hardened steel shot is another purely mathematical question. When a particular form of head of shot has been decided upon, and when a satisfactory method of hardening the shot has been discovered, it will be an easy matter to determine the laws which govern the perforation of iron plates. The quantities to be connected are the velocity, the weight, and the diameter of the shot, and the thickness of the iron plates. It is probable that a series of experiments conducted with plates of tolerably good iron of a uniform quality would be sufficient to afford all necessary information. A few comparative experiments might be made with plates of different qualities of iron but of equal thicknesses.

When opportunity offers, it is intended to repeat and extend the experiments of Robins and Hutton with the whirling machine. It is evident that this chronograph would give the exact time of each revolution of the machine from rest up to the attainment of uniform motion. Each experiment would thus afford a determination of the *law* of resistance of the air to the motion of the particular form of body. If a sufficient fall could be obtained it would be easy to make some very exact experiments on the force of gravity and the resistance of the air at low velocities. Comparative experiments on the velocity of shot and the velocity of the sound of the explosion of the gun may be made, provided the concussion of the air can be caused to break for a moment a galvanic current. If this can be done, the time occupied by the sound in passing over every successive 100 feet can be measured; and when the laws of resistance of the air have been determined, it is probable that the simplest instrument that can be used to find mere initial velocities will be one which measures the comparative velocities of the shot and the sound of the explosion.

The chronograph here described was contrived solely with a view to the satisfactory measurement of the velocities of bodies, and the determination of the resistance of the air to their motion, and without the slightest concern about

the cost or weight of the instrument. Possibly an instrument-maker would construct a chronograph for £100, and a clock for £25. The shed to hold the two might cost £50. Thus the cost would be about £175 ; but to cover all contingencies I would double the above sum and estimate the cost at £350. But, on the other hand, the saving in powder and shot must be considered in making a connected series of experiments. For instance, the chronograph makes 10 records, or more, for a single shot. And further we must allow the value of each record to be at least 10 times the value of that made by an instrument which measures only one interval. So that it seems to me that the new chronograph, in economy of ammunition, compared with any chronograph in use, may be placed at 100 to 1. Extravagant as this estimate may appear, it is really understated. I maintain that any one of the eleven shots already described gives more exact information than all previous experiments made with the same gun fired with the same charge. But there need be no difficulty about cost, for the instrument is already constructed complete in all its parts, and ready to make all experiments required for a perfect system of gunnery in the course of a few weeks. To shew the capability of the instrument, we will suppose the chronograph placed in some central position at Shoeburyness, and provided with wires running to six different ranges, and that no less than six different parties wished to conduct experiments at the same time. Five or ten minutes at least are required to repair a set of screens, but only a few seconds are required to complete the experiment when the gun is ready to be fired. Each party then, as it was prepared, would have to telegraph that it was ready. Communications would be made so as to send the galvanic current through the proper screens, the fly-wheel would be put in motion, the signal to fire would be given, and the experiment would be completed. By each party keeping an account of the exact time of the firing of their guns, they would be able to claim their own records at the end of the day without the slightest difficulty or confusion.

I trust that the reader who has had the patience to follow me through this long account of the chronograph, and of the way of using it, will be aware that many questions have been put to me in the course of the last two years, to which I was not able to reply in a brief and satisfactory manner without opening the whole subject. I hope also that they who have urged objections to my methods will be satisfied that I have provided against all real difficulties, and that where I could not overcome a difficulty I have found a way of avoiding it. The screens are perfectly satisfactory, and looking at the instrument as it stands, I cannot see any point in which greater simplicity is practicable or desirable. Certainly if the fly-wheel could be made to revolve with *perfect uniformity* and with a *known velocity*, the labour of forming a time-table for each experiment would be avoided, but no sensible increase of accuracy would be obtained in the result. Undoubtedly there is trouble attending the reduction of these as well as of all other observations where the greatest attainable precision is required. All this trouble I am ready to take upon myself, if in other respects every facility is given me for completing the proposed work.

In conclusion, I must remind the reader that the questions raised in this tract are purely mathematical and mechanical. I have found it necessary to endeavour to clear the way by shewing the exact value of some formulæ and instruments which have gradually come into use from the absence of some-

thing better and more trustworthy. It is proposed to replace the former doubtful or erroneous conclusions by the results of exact experiments made with the guns and projectiles actually in the service, and so to connect them by comparison and interpolation, that all doubt or uncertainty of the smallest degree shall be utterly excluded. When these facts have been arrived at, all that is necessary for practical purposes will have been obtained, and a theory must be based on these facts. Afterwards the application of the results to supply the wants of the army and navy must pass into the hands of military and naval officers, assisted by chemists and mechanical engineers. And I shall feel that my time has been well employed if my results can be turned to account in providing for the defence of our rights and our home. Although I am convinced that a sincere desire for peace pervades all classes of this nation, yet that is no security for the continued enjoyment of the blessings of peace. It is possible that, like Denmark, we may have war forced upon us. The most likely way to keep the peace is to let it be clearly understood, by all whom it may concern, that we know perfectly well how to use the immense power which we, as a nation, possess. And if as a last resource, and the one which, on the whole, offers the least of evils, we are obliged to send forth brave men to fight in a just cause, we shall have the satisfaction of knowing that we have supplied them with every help which the nation can provide for them in the discharge of their trying duty.

July 3, 1866.

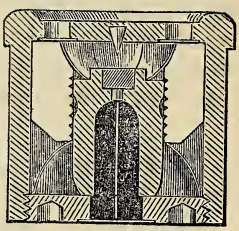
PERCUSSION FUZE,

DESIGNED FOR AND ADAPTED TO THE FORM OF CASE USED FOR SHELLS FOR RIFLED GUNS FOR FIELD SERVICE.

BY LIEUT.-COLONEL FREETH, R.A.

A description has been given of the percussion fuze,* designed by Major Dyer, R.A., and as the subject is treated in a very lucid manner by Capt. Majendie, R.A., I take the liberty of adopting a similar mode of detailing the construction of the interior (or fuze proper) proposed by me.

This fuze consists of the following parts: the body or case, the hammer, the pellet, the cup for guarding detonator, the cup for supporting hammer, the washer for fire-holes, the disc for bottom, and the needle.



The body or case is completed with the several parts appertaining to it in the same manner as described in the paper alluded to; the dimensions are similar, the only difference being that the sides of the case are not perforated.

The hammer is made of the same alloy as the body, and the interior of it is bored slightly conical and roughed with six slight V-shaped grooves; the upper part is cupped out to admit the cup for guarding the detonator; three grooves or air passages are cut at equal distances on the parallel part of the hammer; and the lower end is coned or slightly chamfered to facilitate its descent on the lower cup which supports it until the gun is fired.

The exterior of the pellet, which is made of well seasoned boxwood, is turned to the same cone as the interior of the hammer, the neck of it is the same diameter as the hole in the cup which guards the detonator contained therein.

The cup for guarding the detonator is made of sheet brass, rolled to the thickness of ·003 of an inch, and has six fine slits cut out at equal distances ·1 of an inch long.

This cup is fitted on to the neck of the pellet when inserted in the hammer, so that it is supported by the hammer, the edges of it being flush with the top of the hammer.

The cup for supporting the hammer is made of sheet brass ·005 of an inch thick, and perforated at the top, to allow the pellet to pass through it, and rests flush with the lower end of the pellet on the bottom of the case when screwed home.

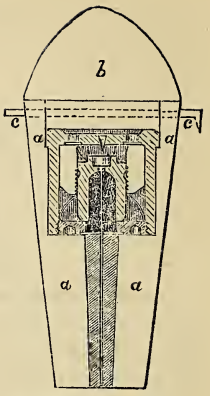
Action of the Fuze. On the discharge of the gun the hammer breaks down by the sudden shock the cup which formerly supported it, embracing firmly at the same time the wood pellet at the lower end, and also withdrawing its support from the cup guarding the detonator; on impact of the shell the hammer forces the pellet on the front cup, which being very sensitive in

* Vide Vol. IV. p. 280.

consequence of the slits, is crushed flat, and the detonator is brought in contact with the needle.

This fuze is sufficiently sensitive to act with half-charges in 12-pr. or 9-pr. B.L. guns, but it may be made more so by the removal of the bottom cup, whereby the hammer will have much less work to do—only to tighten on the pellet; and it has occurred to me that it might be applied in this way very advantageously to shells of the larger natures by the use of an adapter of beech wood, the lower end of which might be stemmed with powder to intensify the force of the magazine.

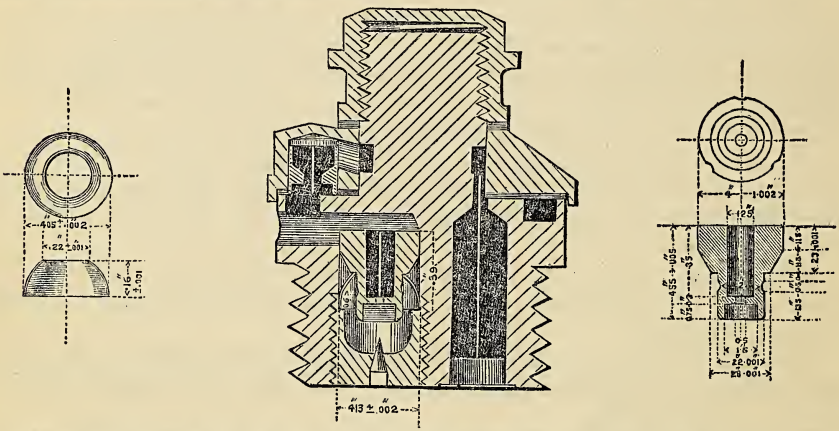
This fuze can be readily distinguished from the other brass percussion fuzes of Sir W. Armstrong's C pattern, and Major Dyer's, by the absence of the safety pin in the former fuze, and in the latter of the heads of the copper screws at the sides. The bottom of the case or body is secured lightly by solder, and the wrench holes filled in also, but it can be easily removed if necessary.



a, Body of adapter.
b, Cap which fits close down on top of fuze and is secured by
c, Brass pin.

The following is a description of a modified pellet which I have proposed for the E time fuze:

This pellet is made of the same alloy as the body of the fuze, and of the form in the accompanying diagram.



It is supported on a cup of sheet brass ·005 of an inch thick. The priming and detonating composition are the same as those used for the pellet of the pattern E time fuze.

It is only necessary in adapting this pellet and cup to the E time fuze to remove the white metal pellet, and then a recess ·41 of an inch in diameter, and ·06 of an inch deep is cut in the screw pin-plug to receive the brass cup; the new pellet is then dropped into the chamber with the cup, and the plug is screwed up again, care being taken not to crush the edges of the cup in this operation.

The E time fuze fitted with this detonating arrangement will have C.S. (cup suspension) stamped on the base.

The paper on "Palliser's (chilled) shot and shell," is postponed until next No.

REPORT

OF

EXPERIMENTS WITH NAVEZ'S ELECTRO-BALLISTIC APPARATUS,*

TO DETERMINE

(1) THE EFFECT OF ELONGATING THE CARTRIDGE ON THE VELOCITY OF THE PROJECTILE.

(2) THE EFFECT OF THE POSITION OF THE VENT ON THE VELOCITY OF THE PROJECTILE.

BY CAPTAIN W. H. NOBLE, M.A., R.A.

ASSOCIATE MEMBER, ORDNANCE SELECT COMMITTEE.

Experiments to determine the effect of elongating the cartridge on the velocity of the projectile.

1. This subject has for a long time attracted the attention of artillery officers, and several important experiments have been made for the purpose of determining the effect of the diameter of the cartridge on the initial velocity of the projectile.

The importance of the question will appear on due consideration of the effects of elongating the cartridge, both with regard to the preservation of the gun and the complete ignition of the charge.

It is evident that if the cartridge was made of the same size as the bore of the gun in which it is fired, the only method by which the gas first developed could penetrate the rest of the charge, is by passing between the interstices of the grains. When, however, the cartridge is to a certain extent elongated, and consequently of less diameter than the bore, the gas can pass along the space left between the cartridge and the top of the bore, and thus facilitate the complete ignition.

This gas also has the effect of causing the shot to move, and so enlarging the space which the powder occupies at the moment of its maximum tension; it thus relieves the gun by causing the initial strain to be spread over a greater surface. The object of the present experiment was to ascertain how far the cartridge could be elongated without seriously reducing the velocity of the projectile.

It is impossible, within the limits of this paper, to dwell on the various scientific points connected with this subject. Colonel Boxer has devoted an

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* Extracted from Second Report on Ballistic Experiments.

important section to it in his *Treatise on Artillery*,* and it is fully discussed in other works on the *Science of Gunnery*.†

2. In 1852, Colonel Palliser, R.A., brought this subject to the notice of the Ordnance Select Committee, forwarding a translation of a paper by Colonel Frederix, Belgian Artillery, on *Gargousse allongée*, and proposing that experiments be made in this country. Accordingly we find that in 1853 a series of experiments were made at Shoeburyness, by firing two 24-prs. side by side at different elevations; one gun using the service cartridge of 5·6 inch diameter; the other elongated cartridges of various diameters, ranging from 5·42 to 4·5 inches.

From these experiments it appeared that the minimum diameter of cartridge that could be used without loss of range was 5 inches.

These results corroborated those previously noticed by Major Mordecai‡ in his experiments on the initial velocity of projectiles fired from a 24-pr. gun, using cartridges of different diameter.

3. No special report appears to have been made of the Shoeburyness experiments of 1853, and the subject dropped until 1862, when it was revived by the late Captain Lyons, R.A., at that time Inspector of Artillery.

This officer, in a *Memoir on the Cause of Failure of cast-iron rifled guns*, remarked on the necessity of making some experiments with elongated cartridges fired from the 68-pr. gun of 95 cwt., and urged its importance to the Ordnance Select Committee, who recommended a series of experiments being carried out;§ it was not however until the beginning of 1864 that all arrangements were completed, and a programme of experiments decided on.

4. Advantage was taken of a comprehensive series of experiments on the endurance of cast-iron guns, to fire a number of rounds from a 68-pr. with cartridges of different diameters and lengths, in comparison with an equal number of rounds with the service cartridge.

The diameters of the cartridges were taken before they were placed in the gun, and the length deduced by observing, with a graduated rammer, the distance from the muzzle to the front part of the shot. When the gun had been loaded, this distance, *plus* the diameter of the shot, being subtracted from the total length of bore, gave the actual length of bore occupied by the cartridge at each round.

It will be observed that there is a slight discrepancy between the lengths and diameters of the cartridges. This was probably owing to some cartridges being rammed up harder than others, and to the difficulty of manufacturing cartridges varying by such small amounts.

The velocity and range of each round was observed, and the following tables give the results.

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* Boxer's Treatise on Artillery, p. 79, sec. 187.

† Piobert Traité d'Artillerie, 1859, p. 449.

‡ Mordecai, Experiments on Gunpowder, p. 288.

§ Report 2334.

Table I.

Abstract* showing the velocity of solid shot fired from a 68-pr. unbushed gun (Expl. No. 242), with the cartridge made up of different lengths and diameters. Calibre of gun 8·12 inches.

See Table II. for ranges.

Charge ..... 16 lbs.
Solid shot, weight ..... 66·5 lbs.
,, diameter ..... 7·92 ins.
Brand of powder, L.G., W.A., 15/8/63, Lot 623.

No wads used.

Date of experiment, 2/2/64.

No. of rounds.	Cartridge.		Observed velocities at 30 yds.			Calculated mean initial velocity.	Remarks.
	Mean length in the bore.	Mean diameter.	Min.	Max.	Mean.		
	in.	in.	ft.	ft.	ft.	ft.	
15	10·37†	7·4	1523·9	1572·7	1543·0	1569·0	
15	10·90	7·5	1519·2	1567·6	1550·4	1576·6	
15	11·58	7·0	1528·6	1561·0	1549·8	1576·0	
15	13·45	6·5	1486·7	1528·7	1513·0	1538·0	
15	15·35	6·0	1448·2	1497·5	1477·8	1502·0	

Table II.

Result of 100 rounds of solid spherical shot, weight 66·5 lbs., fired from the unbushed 68-pr. (Expl. No. 242), to test range, accuracy, and recoil, with elongated cartridges. Charge 16 lbs.

Elevation by spirit level, axis of gun 17·5 feet above plane.

Date.	No. of rounds.	Corrected elevation.	Cartridge.		Mean recoil.	Mean time of flight.	Ranges.			Mean difference of range.	Mean observed deflection.	Mean reduced deflection.
			Gauge.	Mean length in the bore.			Min.	Max.	Mean.			
1864.		° ′	in.	in.	ft.	sec.	yds.	yds.	yds.	yds.	yds.	yds.
Feb. 2.	15	2 17	service 7·4	10·37	6·94	3·43	1119	1336	1225	51·1	5·1	2·9
,,	15	,,	7·5	10·90	6·42	3·31	1092	1326	1190	58·5	2·8	2·5
,,	15	,,	7·0	11·58	7·20	3·41	1121	1321	1221	41·5	3·9	1·6
,,	15	,,	6·5	13·45	6·76	3·27	1114	1300	1173	46·8	3·7	2·2
,,	15	,,	6·0	15·35	6·34	3·39	1166	1261	1200‡	22·5‡	4·7‡	1·5‡
Feb. 4.	5	5 10	service 7·4	10·37	6·07	6·64	1904	2085	1991	55·0	23·3	3·7
,,	5	,,	7·5	10·90	5·92	6·86	1968	2123	2043	54·6	21·6	5·8
,,	5	,,	7·0	11·58	6·35	6·72	1915	2148	2023	84·0	13·5	3·6
,,	5	,,	6·5	13·45	5·97	6·66	1965	2033	1998	26·6	13·3	5·4
,,	5	,,	6·0	15·35	5·55	6·54	1881	1985	1928	38·2	16·2	6·0
	100											

* The time for this experiment was three and a half hours, during which the velocities, length of cartridge, ranges, &c. of 75 rounds were accurately recorded.

† Cartridge supposed to have been rammed up slightly harder than the others.

‡ Means of 11 rounds, the other 4 shots having grazed on the water.

The gun was on a garrison sliding carriage on a dwarf traversing platform, with slope 5°. No compressors were used. The platform was wet throughout.

These results proved that the effect of elongating the cartridge 5 inches, and reducing the diameter of it from 7·4 to 6·0 inches, had the effect of reducing the initial velocity by 67 feet, and the range by 25 yards and 63 yards, at the respective elevations of 2° 17′ and 5° 10′.

5. In order to verify these results, the Committee directed the experiment to be repeated with cartridges of 7·5, 7·4, 7·2, and 7·0 inches diameter.

The following tables give the results.

Table III.

Abstract showing the velocity of solid shot, fired from a 68-pr. unbushed gun (Expl. No. 242), with the cartridge made up of different lengths and diameters.

See Table IV. for ranges.

Charge ..... 16 lbs.
Solid shot, weight .. .. 66·5 lbs.
,, diameter ..... 7·92 in.
Brand of powder, L.G., W.A., 15/8/63. Lot 623.

Date of experiment, 31/3/64.

No. of rounds.	Cartridges.		Observed mean velocity at 30 yards.	Calculated mean initial velocity.	Remarks.
	Mean length in the bore.	Mean diameter.			
	in.	in.	ft.	ft.	
15	10·41	7·4	1548·8	1571·0	No wads used.
15	10·33	7·5	1553·1	1580·3	
15	10·52	7·2	1550·1	1576·3	
15	11·58	7·0	1540·4	1566·6	

Table IV.

Report of firing 60 rounds from the above gun, with cartridges made of different lengths and diameters.

Charge ..... 16 lbs. Solid shot ..... 66·5 lbs.

For velocities, see Table III.

Date.	No. of rounds.	Gauge of cartridge.	Corrected elevation.*	Mean time of flight.	Ranges.			Mean difference of range.	Mean observed deflection.	Mean reduced deflection.
					Min.	Max.	Mean.			
1864		in.	° ′	sec.	yds.	yds.	yds.	yds.	yds.	yds.
March 31	15	7·4	2 17	3·29	1151	1361	1217	39·4	4·4	2·5
"	15	7·5	2 16	3·29	1142	1362	1228	45·7	4·5	2·8
"	15	7·2	2 16	3·45	1190	1356	1258	39·2	6·0	2·0
"	15	7·0	2 16	3·44†	1120	1291	1241†	27·3†	4·6†	2·4†

* Elevation by quadrant.
† Means of 12, the tide being on the range when the last three rounds were fired.

From this experiment it appears that there is no practical loss of either velocity or range by reducing the cartridge (in a gun of 8·12 inches calibre) to 7·0 inches diameter, and that a further reduction to 6·5 inches has a small effect on the velocity, but no practical effect on the range.

It is probable that a cartridge of about 12·5 inches in length and 6·75 inches diameter would give quite as much velocity and range to the projectile, while it would, without doubt, cause a much less initial strain on the gun.

Unfortunately we have no reliable means of determining the pressure of fired gunpowder within the bore of a cannon, and it is therefore impossible at present to ascertain practically the initial strain per square inch, corresponding to different lengths of cartridge. It is, however, self-evident that the greater the space occupied by the charge at the moment of its maximum tension the less will be the initial strain per square inch, and it is probable that a reduction of the 68-pr. cartridge to a diameter of 6·75 inches would have the effect of reducing the initial strain per square inch by at least 150 atmospheres.

It is an error to imagine that a reduction of the initial strain on the gun is necessarily attended with loss of velocity in the projectile.

The initial velocity of a projectile is the sum of the impulses it receives from its first movement till it reaches the muzzle, and depends upon the total pressure exerted, and the space through which this pressure acts.

The initial strain on the gun is another thing altogether, and takes place at the moment of maximum tension in the charge of powder, which, with spherical shot, is very shortly after the projectile has commenced to move, and with most elongated shot is probably before any movement takes place.

It will appear from this that a gun may be very severely strained by a charge which will not give a corresponding velocity to the projectile. It is not the total strain on a gun, corresponding to the recoil, which injures it most, it is the blow or shock which it experiences at the moment of the powder reaching its maximum tension.

It is this which makes gun cotton so destructive. A charge of gun cotton may give a less velocity than a charge of gunpowder, and yet its effect on the gun be very much greater.

The gas in the one case is developed more instantaneously, and the projectile has not time to move, and so relieve the gun, before the tension is at its maximum.

It is this which chiefly caused the bursting of cast-iron rifled guns. Although these guns were fired with a smaller relative charge than when in their smooth-bore state.

The initial strain was, however, greater; and if a cast-iron gun is subjected to a greater initial pressure than the material of the gun is known to bear, there can be but one result*.

Various methods have been proposed for strengthening cast-iron guns by exterior wrought-iron or steel hoops; and guns so strengthened have invariably failed in the inside, where the metal was cast-iron and unable to bear the initial strain brought upon it.

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* See Major Palliser's Treatise on Compound Ordnance.

I believe the results of all these trials would have ended differently had the cartridge used with the cast-iron rifled gun been judiciously elongated.

If the initial velocity of the projectile had been affected by this, the addition of a little more powder would have restored any loss, while the elongation of the cartridge, by spreading the strain over a greater surface, would have considerably reduced the initial strain on the gun, and the consequent tendency to burst.

It is hoped that cast-iron gun *barrels* may never be employed in this country for rifled pieces, but if such should be the case, a trial should be given to elongated cartridges, which, there is every reason to believe, will have a great effect on the endurance of the gun. Meanwhile, it might be worth while to alter the dimensions of the present service cartridge with all smooth-bored cast-iron guns. It has been proved that with the 68-pr. cartridge an elongation of nearly two inches does not effect the velocity and range, and it is evident that the initial strain must be reduced by the use of a cartridge 12 inches long instead of 10.

Experiments to ascertain the effect of the position of the vent on initial velocity.

7. This question has been for a long time in much obscurity, and has afforded grounds for many conflicting opinions. No satisfactory experiments had ever been made on the subject; for although Hutton and Mordecai instituted investigations in this direction, they gave their attention principally to the effect of the position of the vent *on the escape of the fired charge through it*, and not to its influence on the ignition of the gunpowder.*

Under these circumstances it was most desirable that the matter should be cleared up and set at rest, and in the latter part of 1862, Brigadier-Gen. J. H. Lefroy, R.A. submitted the following memorandum on this subject to the Ordnance Select Committee, of which body he was then Secretary.

General Lefroy says :—

"Piobert remarks" (*Cours d'Artillerie*, p. 207), "that experience has demonstrated the advantages of the usual position of the vent, namely, at the end of the bore, 'but,' he proceeds, 'since the rate of burning of the powder has something to do with the most advantageous position to give to the vent, it results that experiments made in different countries on the position which gives the greatest initial velocity to the projectile have not always agreed.'

"This qualification shows that there is an ample field for fresh inquiry; and since we can now ascertain initial velocities with a facility unknown when the above passage was written (1835), and are at the same time seeking to modify and control the rate of burning of our powder, it would appear a favourable moment for taking up the question, which is new in this country.

"The general arguments for placing the vent at the bottom of the bore are: (1) It is favourable to the complete expulsion of the cartridge. (2) The gas first developed has the cubic space occupied by the charge

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* Colonel Boxer's Treatise on Artillery, p. 61, sec. 158.

to fill before it acts on the ball; this latter, therefore, when stirred from its place, is actuated by a greater pressure than if it were moved by the ignition of the portions of the charge immediately next it. (3) There is supposed to be less force lost by the vent, but I am unable to see why. (4) Actual experiment with a musket in 1817 (*Memor. de l'Artillerie*, Part IV. p. 244), is said to have shown that with the length of charge divided into 18 parts, the greatest velocity was given with the vent at $\frac{1}{18}$th from the back end, and the greatest recoil with the vent half-way up the charge.

"The first of these reasons is the only one that seems entitled to much respect; with very heavy elongated shot it is an actual advantage to overcome their inertia before a great force of gas comes upon them; it reduces the tendency to form dents in the bore, and reduces generally the strain on the sides and bottom of the bore. These shot have a much lower initial velocity than round shot, there is after all as much, and often more time for the combustion and the expansion of the gas by its own heat, before they leave the bore, even if they should move sooner, than if they were round shot.

"Experiments with a musket using French powder, of whatever sort it might have been, are evidently no guide whatever for the behaviour of a charge in a gun of 7 to 13 inches calibre, with $2A_4$ powder, or any other very large grain, in very long charges, with a very heavy column to move, and with the retardation of rifling to overcome.

"If these remarks are well founded we may be sure the subject will soon be taken up again, and it appears a peculiarly suitable one for the Ordnance Select Committee to take the initiative in.

"The course I propose is to take a muzzle-loading wrought-iron or bronze rifled gun, with charge exactly two calibres long, and shot exactly double the weight of the round shot. To divide the length of the charge into ten equal parts, and have vents at 0—1—2—4—6—8, &c. so arranged that only one shall be open at a time, the rest closed by a screw plug down to the bottom; and to fire five rounds with each, of three sorts of gunpowder, total 120 rounds, ascertaining the velocity with Navez's apparatus.

"If there is any law of velocity depending on the position of the vent, this will no doubt bring it out, and if it affects one kind of gunpowder rather than another, we shall discover it, and have something better than prescriptive custom to guide us in fixing the best position of the vent of the new family of large guns which are now about to commence their career."

9. From experiments made in France with small arms about the year 1828, Colonel Duchemin was led to believe that the best position of the vent is at $\frac{1}{5}$ to $\frac{1}{6}$ the length of the cartridge measured from the bottom of the bore.*

Hutton's experiments are detailed in Tract 34, Section 86.

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* Mémorial de l'Artillerie, No. 4, p. 233.

The gun he employed threw a spherical shot of 1·044 lbs., with a charge of 1 lb.

The cartridge was ignited in three different positions; viz. in front, in the centre, and in rear, and the velocities were :—

In front	2020 feet.
In centre	2124 „
In rear	2036 „

Thus igniting the cartridge in the centre was attended with an increase of velocity of about 100 feet.

Hutton's experiments, however, in this direction were but few, carried on with very small guns, and were evidently so contradictory that in spite of the above results he remarks :—

"It appears that there is no difference caused in the velocity or range by varying the weight of the gun, nor by the use of wads, nor by different degrees of ramming, nor by firing the charge of powder in different parts of it."* It is impossible to account for this opinion.

10. A few experiments on this subject were made by the late Captain Lyons, R.A., Inspector of Artillery, in connexion with the proof of ordnance.

The first of these took place at the proof of the first 10·5-inch wrought-iron gun constructed by Sir William Armstrong; the details of this experiment are given in the Report of Ballistic Experiments (Noble), 1861-2, p. 70, Section 15.

From the results of this experiment Captain Lyons was induced to make further investigations at the proof butt, Woolwich, by firing cartridges in different positions and under various circumstances.

The velocity of the projectile was not observed during these experiments, which were carried out in connexion with the proof of vent pieces in Armstrong 7-in. breech-loading guns. Captain Lyons states that his object in igniting the charge in the centre was to diminish the length through which the gas first formed would have to travel before it met the shot, and thus equalize the strain over the powder chamber.

His idea was, that by igniting the cartridge at the rear the strain on the vent piece was not commensurate with the strain on the gun, or with the amount of the charge employed.†

Thus in proving vent pieces, the strain which ought to have been borne by the vent piece was really borne by the gun, which showed it by indentations in the shot chamber.

In order to test these suppositions, a round was fired by igniting the cartridge at one third of its length from breech piece.

The effect of this round was to break the vent piece into five pieces, and partly melt the copper cup used at proof.

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* Tract 34, Section 122, p. 79, Vol. III.

† Captain Lyons's report to Ordnance Select Committee, 13/5/62, Minute 6584.

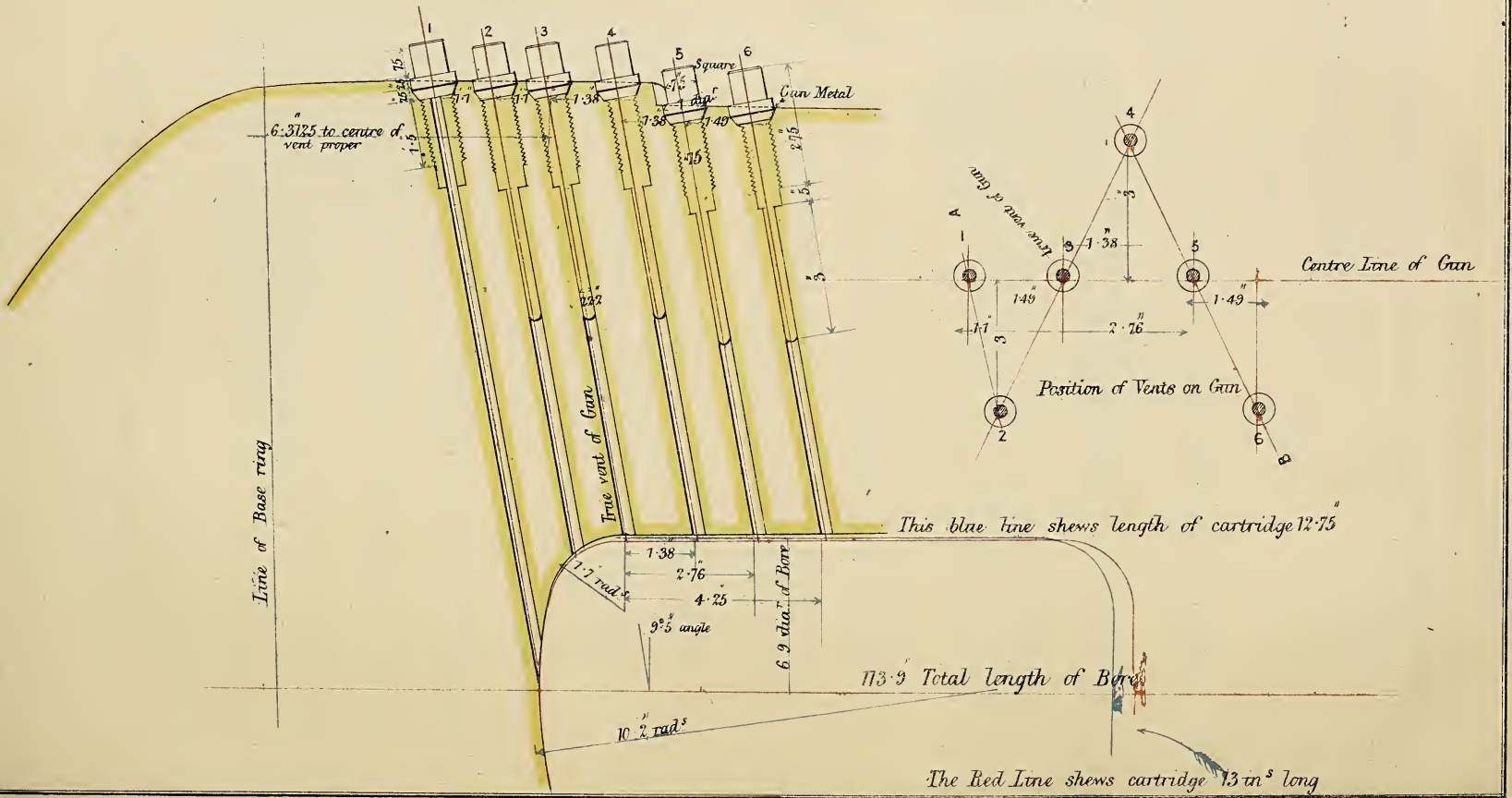
EXPERIMENTAL VENTING FOR 68 Pr BRASS BLOCK WITH 6·9″ BORE

Scale 3 Ins 1 Foot

Pl. 17

W
1851

SECTION ON RED LINE A B



Day & Son (Limited) Lith

The experiment was made as follows :—

A paper tube 0·5-inch in diameter was fixed in the bottom of a 27·5 lbs. cartridge, 18 lbs. of powder were then put in and the tube closed with a piece of calico, and about a dram of fine grain powder put in as priming. The remaining 9½ lbs. were then added, and the gun loaded with this cartridge and a 110-lb. shot. The priming was then fired by means of a magnetic tube, the wires from which passed out through the vent piece.

By this mode of lighting, a very large surface of the charge was acted on, and the initial development of gas much increased; the total initial strain on the gun was, therefore, more severe than if the cartridge had been lighted at the end, but this strain was more equally divided, it did not take place as formerly, chiefly in the shot chamber, but was spread over the powder chamber, and acted with considerably increased force against the breech of the gun, which in muzzle-loading guns is the strongest part, and in breech-loaders the weakest.*

11. No further experiment on this subject seems to have been carried on up to the date of General Lefroy's memorandum.

In consequence of his recommendation, the Committee decided to institute a course of experiments for the purpose of determining the effect on the velocity of the projectile, due to igniting the cartridge in different positions.

The gun employed for this purpose was a bronze one of 122 cwt., which was cast as a block in the Royal Gun Factories in 1860, and was of the outside dimensions of a 68-pr.; *vide* tracing. It was bored to the calibre of a 42-pr., viz. 6·9 inches, and was fired with a charge of 14 lbs., and cast-iron solid shot weighing about 41 lbs.

The first series was for the purpose of determining the velocity of the projectile when the cartridge was ignited in six different positions, commencing from the rear, the powder being common service L.G.

The vents were bored as follows :—

No. 1. So that point of ignition should be exactly at the base of the charge.
No. 2. Half-way between No. 1 and the service vent, or No. 3.
No. 3. The service vent.
No. 4, 5, and 6. At the respective distances of 1·38, 2·76, and 4·25 inches in front of the true vent, or No. 3, that is about 1·4 inches apart.

The several positions of the vents are shown in the tracing above-mentioned; each vent was opened as required, all the others being closed by a screw plug, which admitted of removal.

In this manner five consecutive rounds were fired with each vent, and the velocity of the projectile observed.

The experiment was completed in one day, and every round was fired under the same circumstances.

The following table gives the results.

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* Lately Mr Whitworth appears to have adopted this method of igniting in the centre by means of a tube in the cartridges for his 70-pr. gun, tried by the Armstrong and Whitworth Committee.

Table V.

Abstract showing the velocity of solid spherical shot, fired with a charge of 14 lbs. L.G. powder, from the bronze 68-pr. block, bored up to 42-pr. calibre. (Expl. No. 202).

The cartridge was ignited in six different positions, as shown in the tracing. The gun was washed out after every five rounds.

Weight of gun	122 cwt.
Length of bore in calibres	16·5
Diameter of bore	6·9 ins.
Charge	14 lbs.
Length of cartridge filled	12·75 ins.
Diameter	6·80 „
Mean weight of shot	40·89 lbs.
„ diameter „	6·746 ins.

No. of vent.	No. of rounds.	Mean recoil.	Observed velocities at 100 feet from muzzle.			Calculated mean initial velocity.	Difference from greatest velocity.	Remarks.
			Min.	Max.	Mean.			
		ft. in.	ft.	ft.	ft.	ft.	ft.	
1	5	not obs.	1714·4	1741·7	1726·5	1773	87	Brand of powder, L.G. No wads used. The cartridge was rammed up to the same place each round. Date of experiment, 17/12/63.
2	5	1 9	1720·5	1770·2	1735·8	1782	79	
3	5	1 11	1722·3	1752·0	1742·0	1789	72	
6	4	0 0	1747·7	1792·9	1763·5	1811	50	
4	5	2 0	1744·1	1795·5	1768·1	1816	45	
5	5	2 1	1792·9	1829·2	1812·5	1861	0	

From this table it appears that the position of the vent exercises a very material effect on the velocity of the projectile. The greatest velocity was given by No. 5 vent, or when the cartridge was ignited near its centre; and the least with No. 1 vent, or when the ignition took place at the rear.

The service vent was No. 3, and the difference between the velocity obtained by its use and by that of No 5, amounted to 72 feet per second.

In all cases the loading was performed in the same manner, and the cartridge or serge bag appeared to be equally well removed from the gun by every description of vent.* No appearance of extra fouling was observed

* The competitive Armstrong muzzle-loading 70-pr. gun, used by the Armstrong and Whitworth Committee, was vented so as to strike the cartridge near the centre. This gun fired 3000 rounds without any difficulty occurring in the removal of the cartridge. It is possible, however, that in firing salutes with blank reduced charges, there may be some tendency to jam the remains of the cartridge against the end of the bore and so leave a residue.

with any vent, and the only apparent difference was in the velocity of the projectile.

12. The Committee directed that the trial of the four last vents, viz. 3, 4, 5, 6, should be continued with a larger-grained powder, or L.G. rifle powder.

The results of the second series are given in the following table.

Table VI.

Abstract showing the velocity of solid spherical shot, fired with a charge of 14 lbs. of L.G. rifle powder, from bronze 68-pr. block, bored to 42-pr. calibre. (Expl. No. 202).

The cartridge was ignited in four different positions, as shown in the tracing.

Mean weight of shot..... 41·03 lbs.
,, diameter ,, ... 6·746 ins.
Length of cartridge ..... 13 ins. Diameter 6·8 ins.
Brand of powder ..... A_4, 30/4/63, Lot 576.
Charge ..... 14 lbs.

Date of experiment, 17/2/64.

No. of vent.	No. of rounds.	Observed velocities at 100 feet from muzzle.			Calculated mean initial velocity.	Difference from greatest initial velocity.	Remarks.
		Min.	Max.	Mean.			
		ft.	ft.	ft.	ft.	ft.	
3	5	1726·0	1778·2	1747·5	1794	101	
4	5	1757·8	1812·0	1787·7	1836	59	No wads used.
5	5	1820·4	1862·1	1845·4	1895	0	The cartridge was rammed up to the same place each round.
6	5	1631·4	1885·1	1811·1	1860	35	

The velocities with No. 6 vent, although high, are irregular.

The gun was washed out every five rounds.

From this table it appears that with rifle L.G., which is a larger-grained powder than the common L.G., the difference in velocity due to the point of ignition of the cartridge is more marked.

No. 5 continues to hold the first place, and the difference between it and No. 3, or the service vent, is no less than 101 feet.

It may also be observed that the velocities with all the vents are larger than those given in Table V.

13. As the Special Committee on Gunpowder had been carrying on experiments with a new class of powder, denominated "pellet powder," it was resolved to fire a few rounds with this powder in comparison with L.G. and rifle L.G.

The pellets were made up into cartridges in the usual serge bags, and the experiments conducted in the same manner as before. The following table gives the results.

Table VII.

Abstract showing the velocity of solid spherical shot, fired from the bronze 68-pr. block (Expl. No. 202), with "pellet" powder similar to that used by the Committee on Gunpowder.

Mean weight of shot	41·2 lbs.
„ diameter „	6·746 inches.
Length of cartridge before loading	13·5 „
„ „ after loading	11·5 „
Diameter of cartridge	6·6 to 6·8 ins.
Brand of powder, "indented pellet"	9/9/64, unglazed.
Charge	14 lbs.
Weight of one pellet	80 grains.

Date of experiment, 13/9/64.

No. of vent.	Total No. of rounds.	Distance of point of ignition from rear of cartridge.	Observed velocities at 100 feet from muzzle.					Mean observed velocity.	Mean difference of velocity.	Calculated mean initial velocity.	Difference from greatest initial velocity.	Remarks.
			1	2	3	4	5					
		in.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	
1	3	0·0	1889·4	1855·7	1835·5	—	—	1860·2	19·5	1910	41	No wads used. The cartridge was rammed up to same place each round.
3	5	2·20	1812·0	1922·3	1915·2	1903·4	1835·7	1877·7	43·1	1928	23	
4	5	3·58	1898·7	1851·0	1910·5	1891·7	1901·0	1890·6	15·8	1941	10	
5	4	4·96	1906·1	1880·5	1908·4	1903·8	—	1900·0	5·6	1951	—	
6	3	6·45	1862·1	1844·3	1898·7	—	—	1868·4	20·2	1918	33	

The velocities given by this powder are higher than those given by rifle L.G. powder; this is probably owing to the lighter specific gravity of the "pellet" powder.

It appears that No. 5 vent has still a slight advantage, although the differences are not nearly so marked as was the case with L.G. and rifle L.G. powders. This is probably owing to the ease with which the gas first developed can penetrate the rest of the cartridge through the large interstices between the "pellets."

14. From these experiments the following conclusions may be drawn :—

(1) With L.G. and rifle L.G. powders, where the grains are comparatively small, the initial velocity of the projectile is considerably influenced by the position in which the cartridge is first ignited. The velocity increases as the point of ignition moves from the rear, is greatest a little behind the centre, and then diminishes.

The velocity is greatest when the point of ignition is at about $\frac{4}{10}$ths the length of the cartridge from the rear.

(2) The velocity of the projectile is least when the point of ignition is at the rear of the cartridge.

(3) No particular disadvantage was observed consequent on igniting the cartridge near the centre.

(4) The velocity of a spherical projectile is increased by the use of rifle L.G., which besides being a larger-grained powder than L.G., is of slightly less specific gravity.

(5) The results with a very large-grained powder or pellet powder are the same, only modified, that is, the differences between the velocities given by varying the point of ignition of the charge are not so marked as with smaller-grained powder.

These experiments have proved that more work can be obtained from a given charge of powder by igniting the cartridge at a point $\frac{4}{10}$ths of its length from the rear, than by igniting it in any other position. The effect, however, which this will have on the initial strain in the gun and, consequently, on its endurance, is a matter for separate consideration.

THE WOOLWICH GUNS:

THEIR PROJECTILES, CHARGES, &c.

BY

CAPTAIN E. A. SLESSOR, R.A.

ASSISTANT CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

As some of the guns, rifled on what is called the "Woolwich system," are now approved for service, a short account of them, and of the projectiles and charges used with them, may be acceptable to officers at out-stations who have no means of seeing them. Some of the information contained in the following paper has been taken from the reports of experiments carried on by the O. S. Committee, and from a pamphlet by Major Palliser, and for some I am indebted to Captain Molony, R.A., Captain Instructor, Royal Gun Factories.

The natures of guns at present, made on the "Woolwich system," are the 7-in. and 9-in., and 7-pr. mountain gun.

The first two are wrought-iron muzzle-loading guns, made on Sir William Armstrong's coil system. The 7-pr. will be described afterwards.

The 7-in. M.L. wrought-iron gun is made of two sizes, one of 7 tons for land service, and one of 6½ tons for sea service. They are rifled with three grooves the form of groove being a modification of the French, with a uniform spiral of one turn in 35 calibres.

Fig. 1.

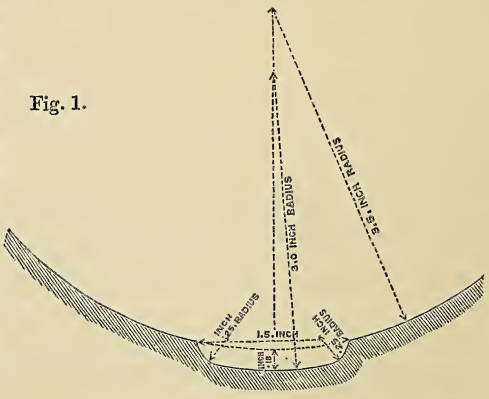


Fig. 1 gives all the particulars as to the shape, size, &c. of the grooves.

Some 8-in. guns have been made, but the rifling to be applied to them has not yet been settled, so they cannot be included in the list of "Woolwich" guns. They will only be used for sea service. They weigh 9 tons.

The 9-in. M.L. wrought-iron gun weighs 12½ tons, and is rifled with six grooves of the same shape as those of the 7-in., but with a spiral increasing from 0 at the breech to 1 turn in 45 calibres at the muzzle.

Object of increasing spiral.

The object of rifling a gun with an increasing spiral is to decrease the strain on the powder chamber of the gun, as the projectile has only to move directly forward at the moment of starting, instead of being forced simultaneously into rotation. This of course also has an effect on the vent, it being found that, of two 7-in. guns, fired under the same conditions for a number of rounds by the O. S. Committee, the vent of the one with the uniform twist was more enlarged than that of the one with the gaining twist. The difference was small but decided.

Difference of initial velocity.

Owing, however, to the shot leaving its seat in the gun with the gaining twist more readily than in the other, less of the powder charge is consumed before it moves, and the initial velocity will be slightly less, being in a proportion of 1444 to 1465 feet per second.

This difference in velocity, however, is recovered during flight, owing to the front studs being smaller, and offering therefore less resistance to the air. The difference of initial velocity will represent the amount of relief to the powder chamber.

These experiments shewed no difference of any practical importance between the two guns, as to range or accuracy.

Projectiles for the 7″ and 9″ guns.

The projectiles for these two guns are fitted with rows of gun-metal studs, screwed in, rounded to fit the grooves, two in a row; the number of rows corresponding to the number of grooves in the gun.

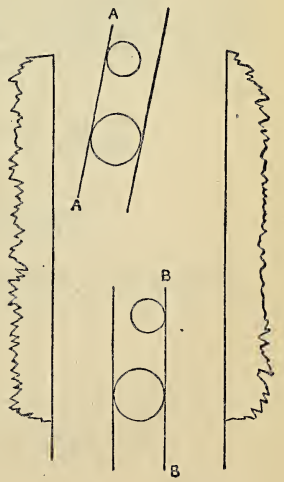
For the 7-in. gun with uniform twist, the two studs are of the same size, but for the 9-in. gun with increasing twist, it is evident that if they were of the same size, the front part of the shot would have a tendency to rotate more rapidly than the back part, so that, even if the gun could be loaded, on leaving, either the front studs would be torn off, or the shot would jam.

The French have only one stud in this case, so that the shot leaves the gun with only one bearing, which would be likely to affect the accuracy of the shooting.

Major Palliser, to remedy this, proposed to make the front stud smaller than the back one, the latter fitting the groove. Fig. 2 (not to scale) represents a section through the bore of a gun with an increasing twist, with a projectile in the position the studs would occupy at the breech and muzzle, without taking friction into account.

The line *AA*, touching the driving sides of the studs (or the sides which bear against the grooves on leaving the gun), makes with the axis of the

Fig. 2.



projectile, or a line parallel to it, an angle equal to the angle of rifling at the muzzle, viz.: 1 turn in 45 calibres, while the line *BB*, touching the other sides of the studs, makes with the same line an angle equal to the angle of rifling at the breech, viz. *O*.

The difference in the size of the studs, therefore, depends on the pitch of the rifling, and the distance they are apart, and this again on the length of the projectile.

When the shot enters the gun, the front stud touches the side of the groove on the bearing or driving side, but as it goes down, it gradually approaches, and when home, bears against the opposite side of the groove.

Theoretically, on firing, the front stud would not touch the groove on the bearing side until the projectile reached the muzzle of the gun, the back one sustaining all the friction consequent upon rotation, but, practically, this friction is so great that the bearing side of the back stud is considerably worn away, and the front one comes to bearing before it otherwise would, so that the projectile leaves the gun steadied by two bearings.

Different kinds of projectiles.

There is at present only one sort of projectile actually approved for the 7-in. and 9-in. guns, viz. common shell; but some of the following will probably be introduced, if not all, viz. chilled shot and shell, cast-iron double shells, Colonel Boxer's shrapnel shell for rifled ordnance, and Lieutenant Reeve's case shot.

Common shell.

The common shell is cylindro-conoidal in shape, about three calibres in length, fitted with rows of studs as described, and lacquered inside to prevent excessive friction, and consequent premature explosion, of the bursting charge, from the rotation during flight. The fuze hole is fitted with what is called the F bush, which is conical inside, like the fuze holes of common smooth bore shells, but larger. (A few were issued at first bushed to the Moorsom gauge).* The F bush receives Pettman's new general service percussion fuze, and Colonel Boxer's new wood time fuze for M.L. ordnance. The fuze hole is countersunk ·1 inch.

These shells have two holes in the head for the claws of the extractor to catch in.

The 7-in. shell weighs,	empty,	106 lbs. 12 oz.,	filled,	115 lbs. 2 oz.
The 9-in. "	"	" 232 lbs.	"	250 lbs.

The 7-Pr. M.L. Gun for Mountain Service.

Three guns of this calibre have been made—

Bronze 3-prs., rifled, of	229 lbs.
Steel guns	"	191 "
"	"	155 "

* These bushes are to be taken out, and the shells re-bushed with the F bush.

They are rifled with three grooves, having a uniform spiral of 1 turn in 20 calibres.

The gun should weigh not more than 200 lbs., so it is probable that one of the steel guns will become the service pattern. They were made for special service in Bhootan.

Projectiles.

The projectiles for this gun consist of a common shell and a case shot of Lieut. Reeve's pattern. A shrapnel, of Colonel Boxer's new pattern for rifled ordnance, has also been proposed.

The shell is 2½ calibres in length, lacquered inside, and fitted with three rows of zinc studs, two in a row, fastened in by being compressed into undercut holes. The fuze hole is of the same size and shape as that of a common smooth-bore shell, and takes Pettman's land service fuze, and a wood time fuze of Colonel Boxer's. This differs chiefly from the common in the composition bore being lined with a paper cylinder, and in the head being closed with a brass screw plug with a centre pin. Quickmatch is secured round the pin, passing out through two fire holes, and is laid in a groove round the outside of the head of the fuze. It is protected by a band of copper and tape, which is removed when the shell is in the bore, thereby exposing it to the flash of the discharge.

The object of this arrangement is to prevent the fuze being extinguished on the shells entering an earthwork, and also to protect the burning composition from the action of the air, which would affect the rate of burning in proportion to the velocity the shell was travelling at. This fuze is the same size as the common, but a little longer, to give room for the plug.

It only differs from the fuze used with the 7 and 9-inch shells in being smaller. They both contain 2 inches of composition.

The shell weighs, empty, 6 lbs. 14 oz.; filled, 7 lbs. 4 oz.

The case shot is of Reeve's pattern, and weighs 4 lbs. 12 oz.

Charges for the Woolwich gun.

There are three charges each for the larger natures, called the battering, service, and saluting charges. The battering charge would only be used with solid shot against iron plating.

They are as follows:—

in.	Battering.	Service.	Saluting.
9	43 lbs.	30 lbs.	15 lbs.
7	22 "	14 "	10 "

The 7-in. cartridge contains 8 oz., and is conical in shape, with one braid hoop. Rifle L.G. powder is used for all.

THE PRESENT STATE OF THE ARTILLERY QUESTION.

BY

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PROFESSOR OF ARTILLERY, ROYAL MILITARY ACADEMY, WOOLWICH.

From the Journal of the Royal United Service Institution, Vol. IX.

THE subject that I have to bring before you this evening presents so many difficulties, that in attempting to lecture upon it I am afraid I shall be considered rather presumptuous. As, however, one of the great objects of this Institution is to discuss such subjects, I thought that, being a member, I should not refuse, when requested by the Council and several of my own brother Officers, to read a paper on the "Present State of the Artillery Question."

There are doubtless many of my brother officers who could give you a better and more interesting lecture than the one you will hear to night, but none would I think take more pains than I have done to look at the various questions in an impartial spirit.

I shall endeavour in the following observations to keep to facts and principles, and to avoid mere opinions or personal remarks; but shall necessarily be compelled to review briefly the constructions and proposals of several inventors. Many confused notions which unfortunately still prevail, may I think be cleared away by dividing the subject into distinct branches, and treating each of these separately. I propose then to consider—

(1) The materials for ordnance.
(2) Methods of construction.
(3) Systems of rifling.
(4) Ordnance of different services.

Before proceeding, I will, however, remind you, as shortly as possible, of a few elementary principles relating to the strains exerted by the gas from the gunpowder upon the metal of a gun; for it is only by applying these,

that opinions of any value can be formed respecting the relative merits of different materials and constructions.

When a charge of gunpowder is ignited in the bore of a gun the gas exerts equal pressure in every direction, and therefore, neglecting windage, the pressure on the bottom of the bore is equal to that on the base of the shot, and the pressures on the top and bottom as well as those on the sides of the bore balance each other. As the shot moves towards the muzzle, so will the space in which the gas is confined be increased, and the pressure be decreased. It is evident then that the thickness of metal may (as it always is) be safely reduced from breech to muzzle. A curve representing the pressure of the gas along the bore might be constructed on the assumption that the whole charge is converted into gas before the shot moves, but this is not the case in practice; in fact, as we know, the amount of gas generated, previously to motion being communicated to the projectile, varies according to circumstances in different guns.

The force exerted by the gas produces a double strain inside the bore—a *tangential strain*, tending to rend the metal lengthwise (through *AB*, Fig. 1); and a *longitudinal strain*, which tends to fracture the gun across (through *CD*), or to drive out the breech.

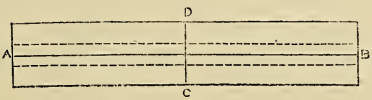

Fig. 1.

The most important point to consider is the *initial strain*, or that to which the metal is subjected before the shot moves; for the gas then exerts its maximum pressure per square inch, and it is this first severe strain that usually causes the destruction of the gun. Now, in ordinary cases, the *initial* pressure exerted at the bottom of the bore by a *given charge* depends upon the amount of force necessary to set the shot in motion, for the greater this force, the longer is the time allowed for the ignition of the powder before the gas can expand.

In comparing then the strain in different guns, it is necessary to consider the resistance the projectile opposes in each case to the force of the gas, or in other words, the work the gas has to perform in putting the shot in motion. For instance, in a smooth-bore gun the spherical shot has merely to be rolled along the surface of the bore, and is therefore probably set in motion when only a small portion of the powder is converted into gas. Should a cylindrical shot be fired from the same piece, there will be a considerable amount of friction between the shot and the bore, which must be overcome and cause delay. In a rifled gun additional work must be expended in giving a rotatory motion to the shot; besides which, the area of projectile presented to the force of the gas is much smaller for a given weight of shot in a rifled gun, than in a smooth bore piece.* It is thus easy to account for the great proportional strain caused by a charge of powder in a rifled gun.

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* In all these cases it must be remembered that although the actual differences in time elapsing between the ignition of the powder and the moving of the shot under various circumstances may be very small indeed, the ratios of the times may be high.

Independently, however, of the increased strain, the grooving of the bore weakens the metal, especially if cast.

Before passing on to consider the materials for ordnance, I must also remind you, that if a gun consists of one solid mass of metal bored out, the exterior portions take but a small share of the strain. I need not dwell on this point, which has been so fully explained by Mr Mallet, Captain Blakely, and others; and you are doubtless aware of the several proposals made and some of the methods adopted for equalizing the strains upon different portions of the metal of a piece of ordnance.

Materials for Ordnance.

The four materials generally used for ordnance are bronze, cast-iron, wrought-iron, and steel. In selecting a material for ordnance it must be remembered that it will not be subjected to a mere variable pressure, but that the force of the gas is percussive, resembling a blow rather than a pressure, and therefore that the tenacity of a metal is not always a criterion of its suitability for guns. The properties especially required in a metal for cannon are elasticity, toughness (tenacity combined with flexibility), and hardness; ductility will allow a greater margin of safety beyond the elastic limit, but the strain should, if possible, be confined within this limit.* It is also important that a material capable of being manufactured with certainty be chosen, and that both the material and the method of construction be not too costly.

Bronze is sufficiently tough, and can, with skill and care, be cast so as to be uniform in quality, but it is costly and too soft for the bores of rifled guns; it does not corrode like iron, and therefore requires no painting.

Cast-iron possesses the necessary hardness, but is very brittle, and, even with the greatest care in casting, is of uncertain tenacity. The Americans have of late greatly improved the quality of the cast-iron ordnance by the selection of the most suitable ores, and by taking means to render uniform the contraction of the different portions of the metal in cooling; nevertheless, cast-iron cannot be used for rifled guns, unless they are fired with very small charges.

Many attempts have been made to strengthen cast-iron guns by shrinking or driving wrought-iron or steel rings or tubes over the breech; the jacket thus applied, being in a state of tension, should take a fair share of the strain; and as the cast-iron will be compressed, it will be in a condition favourable to resistance to strain. Numerous experiments have, however, shewn that cast-iron guns strengthened on the outside will not stand the great strain caused by firing heavy elongated projectiles with even moderate charges and this result has been confirmed by the many failures of the Parrott rifled guns in America. A better plan is to place the wrought-iron or steel inside the cast-iron, as proposed by Major Palliser, the stronger metal being then in the position where it is the most required.

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* According to Barlow, no thickness of metal can permanently resist an internal strain greater than the tensile strength of the material.

Wrought-iron is an excellent material in most respects for ordnance; it is exceedingly tough, and although not so hard as cast-iron or steel, and therefore less able to resist injury from the action of powder and shot in the bore of a gun, it is not liable to snap like the far more tenacious material steel, and will withstand a greater moving or percussive force. Soft iron is preferable to the harder qualities, for, as Kirkaldy remarks, "Although the softness of the material has the effect of lessening the amount of the breaking strain, it has the very opposite effect as regards the working strain. This holds good for two reasons: first, the softer the iron the less liable is it to snap; and second, fine or soft iron, being more uniform in quality, can be more depended upon in practice." It is difficult to obtain large masses of wrought-iron without slight flaws, caused by the cinder and impurities not thoroughly got rid of in the working of the metal; but such flaws are generally of far less consequence than cracks of equal size in cast metals, and do not, like the latter, indicate the speedy destruction of the material; flaws across the fibre of the metal are necessarily dangerous. Wrought-iron, in consequence of its toughness, possesses another great advantage over cast-iron or steel; when fractured it does not, like those brittle metals, fly into a number of destructive pieces, but its failure is gradual, it may be easily noticed, and so injury to the gunners may be avoided.*

Cast steel being exceedingly hard and elastic, is well adapted for the bores of guns; but although its tensile strength is very great, it is liable to snap without warning when exposed to strain suddenly exerted. However, the steels now made for ordnance, both in England and on the Continent, are much softer and tougher than ordinary cast steel of good quality. The steel used for the bores of our large guns is tempered in oil, by which means it is rendered both harder and tougher.

Great difficulty is still experienced in obtaining large masses of cast steel of uniform quality, but since the successful productions of Krupp and some of our own manufacturers, it is to be hoped that this objection will be before long overcome. There remain, however, two other rather formidable objections to the employment of steel alone, viz. the great cost of the metal, and its tendency, when fractured, to fly into a number of destructive pieces, which render it less suitable than wrought-iron for the exterior of a gun. By hooping steel with wrought-iron, the endurance of the former is doubtless much increased, and its destruction is less dangerous.†

In the above remarks on wrought-iron and steel, I have not attempted an inquiry into the best methods of producing these materials; I will only remark that by the adoption of the Bessemer process of conversion, the cost of wrought-iron and steel would be much reduced, but that further experiments are required before the Bessemer metals could be safely employed in the manufacture of ordnance.

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* "Out of nearly 3000 guns made on this principle no one gun has burst explosively."—Sir W. Armstrong's Evidence, Report on Ordnance, p. 134.

† That wrought-iron hoops will prevent dangerous results when the inner steel tube gives way has been shown in many of the late trials of ordnance.

Methods of Construction.

Let us now consider the methods of construction. There is little doubt but that by casting a gun in one mass much time and expense in manufacture is saved, and that many difficulties experienced in making guns in different parts are avoided. At the same time it has not yet been proved that a material of sufficient strength, combined with uniformity in quality, can be obtained for casting into heavy ordnance, which will be subjected to the strains of large charges of powder. Cast-iron is too uncertain in character, bronze is too soft and costly, and steel, as I before pointed out, is very expensive; it is a dangerous material when fractured, and has not yet been sufficiently tried to prove its fitness for very large guns (of over 7″ calibre).

Another method is to form the gun out of one solid forging, and this has been strongly advocated, but has also been utterly condemned by good authorities on the subject.* For guns of very small calibre, it has been adopted with some success, but when a piece weighing many tons is required, it is now pretty generally admitted that this plan will not give the required results. Experiments have shewn that the strength of a forging, like that of a casting, is less as its size increases; but besides this, some parts of a heavy forging will in most cases be more soundly worked than others, and flaws, often running in the worst direction, and which cannot sometimes be detected until too late, will occur.

Another method is to build up or construct a gun out of a number of distinct pieces, and by this plan several important advantages are obtained. 1st, The parts may be of such a size that their soundness may be depended upon. 2nd, Different materials may be used, each being placed at a part of the gun where its peculiar properties are most required. 3rd, The materials may be applied in such a manner that their particles or fibres may run in a direction most favourable for resistance to the strains to which they will be respectively subjected. 4th, That the thickness of metal can be made up of a number of separate layers or tubes placed over one another with regulated tension, so that each may take its due share of strain. There is one most important condition that must not be neglected in building up a gun, viz. to provide against the separation of the different parts, for no matter what materials are used, the gun will have little endurance if the different portions are liable to be shaken asunder by the shocks of successive discharges, or by the blows of an enemy's shot. It must also be obvious that a gun constructed out of a few large heavy pieces will be less liable to destruction, from the causes just stated, than one consisting of a large number of smaller and lighter parts.

We have obtained in this country considerable experience in the manufacture of built-up guns; not, as might have been foreseen, without many disappointments and much expenditure of both time and money. We are not perhaps indebted to any individual for our present system of building

* Mallet, Armstrong, Anderson, American authorities, &c.

up; our experience has been gradually gained, but to Sir W. Armstrong cannot, I think, be denied the credit of being mainly instrumental in combining different principles and improving details, so as to produce an efficient method of manufacture for large ordnance. He has doubtless been ably assisted, both by his own partners and by his assistants in the Royal Gun Factory, but no one can blame him for accepting this assistance or for turning to account the many advantages of his position. In saying this, I do not mean to justify his appointment as Superintendent of the Royal Gun Factories, which it is now generally admitted was a mistake.

The essential features of the Armstrong method of construction, are:—

1st. The disposal of the fibre of the metal round the bore (by coiling), so as to resist the tangential strain, the welds running in the direction of least strain as regards their separation.

2ndly. The employment of a breech piece, to support the bottom of the bore, with the fibre running lengthwise so as to resist longitudinal strain.

3rdly. The shrinking on the different portions, so that the exterior of the gun takes a due share of the strain.*

The separation of the different parts of the guns now made is guarded against, not only by the tension of one part over another, but by means of shoulders and corresponding recesses (Figs. 2 and 3).

Fig. 2.

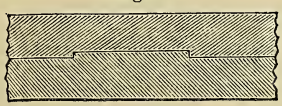

Fig. 3.

These and other details of manufacture, as the decreased diameter of the cascable in the later M.L. guns, the best form for the bottom of the bore, &c., will, I daresay, be fully explained by Mr Anderson, who I understand will give a Lecture here on the 26th of this month. Mr Anderson is, I believe, an advocate of a steel barrel with a closed end, and he will doubtless give reasons for his preference.

I will here remark on the vexed question of coiled iron for the inner tube of a gun. It is often asserted that a sound coiled iron tube cannot be made, and that it is folly to attempt to produce one. I must, however, beg to question this statement. Large numbers of coiled iron barrels have been made, and, notwithstanding slight flaws, have shewn great endurance. If flaws must occur, they are, in a well made tube, so small, and in such a direction, that they are practically of little importance, and do not usually enlarge to a dangerous extent before the gun is worn out.† The coiled iron

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* As proposed by Captain Blakely (late R.A.)

† Sir W. Armstrong pointed out, before a Committee of the House of Commons, the difference between the flaws in the welds of a coiled barrel and in those of a forged solid tube. He said: "In the barrel which is forged solid, the lines of the weld run longitudinally with the bore; now we not

barrels now made of a better iron than that previously used are almost free from flaws, and those that occur are very small.* The fact is, the barrels have been abused, not only for their own imperfections, but also for the failures of the vent pieces.

Several important modifications in manufacture, which will both decrease the cost and increase the endurance of the gun, have lately been proposed in the Royal Gun Factories, by Mr Fraser, the manager and assistant-inspector of machinery. The chief modifications are a reduction in the number of coils; the use of a cheaper iron for the outer coils; the shrinking on of the outer coils and trunnion piece together; and an improved arrangement of shoulders and recesses to prevent separation of the parts. The cost of material is thus reduced, a less quantity of metal is required, much time is saved in the manufacture, and as the parts are large and few in number, and better disposed for mutual support, the endurance will, in all probability, be increased.

Mr Whitworth is a strong advocate of steel for all parts of a built-up gun.† His method of building up differs from that of Sir W. Armstrong:—"The tube of the gun is made taper, being in the 5½-inch bore gun one inch larger in diameter at the breech end than at the muzzle end; then a series of hoops are made, which are screwed together so as to form another tube, that is put on by hydraulic pressure,‡ each layer is put on a little tighter than the succeeding one." Mr Whitworth asserts that pressure is more certain than shrinking; the latter can, however, be done with sufficient accuracy. Captain Blakely also is, I believe, a strong advocate of steel for both inner tube and outer rings, although he has also employed both cast and wrought-iron for portions of some of his guns.

The method of closing the bore of a built-up gun is an important question. The inner tubes of some of the large M.L. ordnance lately constructed in the Royal Gun Factories, as well as those of some of Blakely's guns have what are termed closed ends, that is, the tube is not bored through at the bottom; the solid end of the tube in the service guns is supported by a cascable screwed into the breech-piece, and in some of them also by a shoulder in the breech-piece. Sir W. Armstrong, Mr Whitworth, and Major Palliser use open tubes, and close them by a plug of wrought-iron or copper. The cascable in the Whitworth guns is not like Armstrong's, cylindrical in form, but is shaped into two or more (screwed) cylinders, their respective diameters increasing from bore to breech (see Plate). In closing the bore either of a M.L. or B.L. gun, one important principle should not be neglected, viz. that as the gas exerts an equal force in every direction, the thickness of metal should be as great, or nearly so, behind as

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only derive greater strength from the welds lying transversely to the bore (as in a coiled tube), but we also attain greater durability, because when they run in the direction of the bore, the scour of the gas eats into them, and causes fissures in the most dangerous direction, while in the other case the scour crosses the lines of the welds, and produces very little corroding effect."—Report on Ordnance, p. 134.

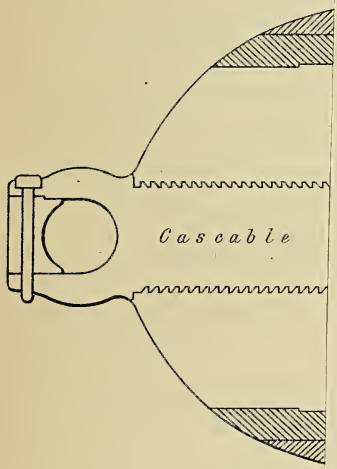
* A tube of coiled iron in a Palliser gun, after several hundred rounds, shewed no sign of a flaw in a weld.

† The trunnion pieces of his experimental guns are of wrought-iron.

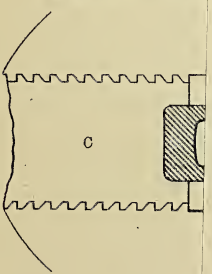
‡ Mr Whitworth's Evidence. Report on Ordnance, p. 126.

D

Breech of G



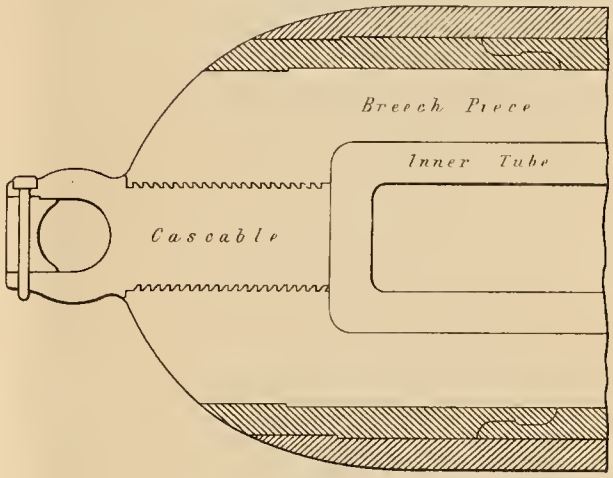
Method of Closi



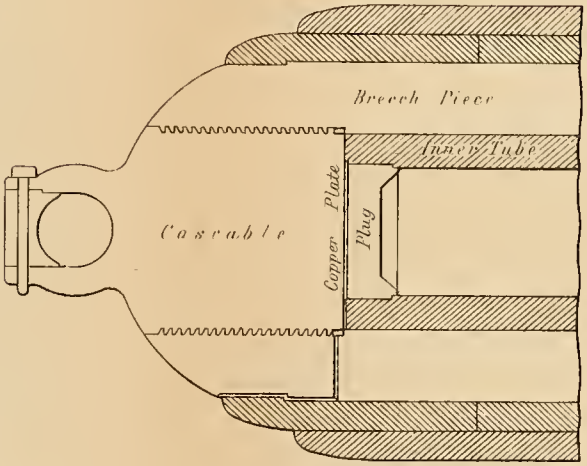
B. *Inner*
C. *Casea*
P. *Breec*
a. *Coppe*

Different Methods of Closing Breech of M.L. Built-up Guns.

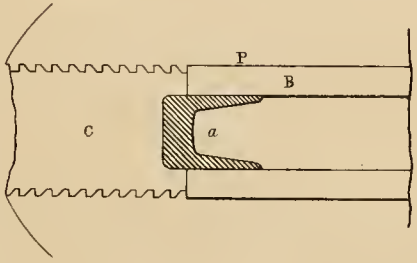
Breech of 9.2 inch Gun.



Breech of Armstrong 10.5 inch Gun.

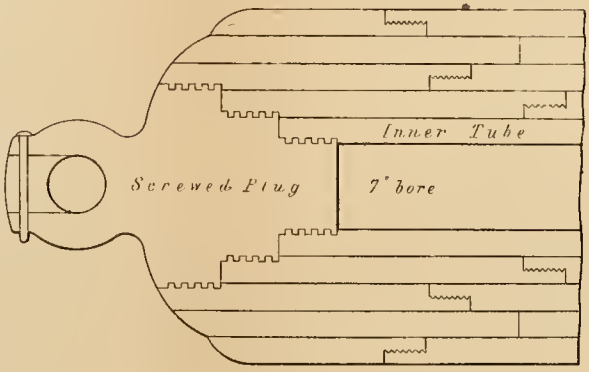


Method of Closing Bore of 64 Pr.



B. *Inner Tube or Barrel*
C. *Cascable*
P. *Breech piece*
a. *Copper Cup*

Breech of 7 inch Gun proposed by Mr. Whitworth.



over the charge. Inattention to this principle, or its sacrifice to other considerations, is a source of weakness in many B.L. guns. One advantage of an open end is, that the metal of the inner tube is relieved to some extent from longitudinal strain.

The relative cost of large ordnance made in different ways is approximately as follows :—

	£			£	
Cast-iron guns	21	per ton.	Krupp's steel guns ...	170	per ton.
Armstrong built-up do...	100*	"	Gun-metal do.	187	"

The latter guns (bronze) are valuable for re-casting. By the adoption of the modifications proposed by Mr Fraser, the cost of built-up ordnance will, it is said, be much reduced, viz. to £40 a ton with a coiled inner tube, and to £55 a ton with a steel tube. Mr Whitworth's guns, like all steel guns, must be very expensive; he told the Committee on Ordnance that his 5½-inch gun, weighing four tons, and made of homogeneous metal (soft steel) costs £700, which is about £175 per ton.†

The following will be, I think, considered sound conclusions on this part of the subject:—

A cast-iron gun strengthened by hoops on the outside will fail when rifled, but by placing wrought-iron or steel tubes inside, better results may be expected.

A heavy rifled gun made in one mass either of cast steel or of forged iron cannot at present be trusted.

By properly disposing and adjusting together a few pieces of moderate size, a heavy rifled gun can be produced, possessing great strength and endurance, at a moderate cost.

The best material for the bore, as also the safest way of closing the inner tube, are still open questions.

Both coiled iron and steel will probably answer for the inner tube; for the exterior portions of a gun, however, there can be no question but that wrought-iron is the best, as well as the cheapest, of the two.

Various opinions are held as to the relative advantages of breech and muzzle-loading ordnance, but the latter would appear to be the best adapted to general service, as they are stronger for equal weights of metal, and simpler in construction. The advantages of loading cannon at the breech are—that a projectile of larger diameter than the bore can be used, and its axis will consequently be stable; that the gun can be loaded when run up, the gunners being therefore less exposed; that the gun can be worked in a smaller space (than a M.L. piece); the cleaning of the bore can be more readily effected, and any ignited substance left in the bore can be seen and removed; also, there is no danger of the shot not being *home*. This plan, however, is attended with the following disadvantages, viz. that the construction is more complicated than that of a muzzle-loading piece; that if the gun be of large calibre, the breech-loading apparatus, when sufficiently

* Lately about £87. † Report, p. 108.

strong and heavy, will be unwieldy; and that with the same weight of metal, the breech-loading is a weaker and less enduring construction than the muzzle-loading.

On the other hand, a muzzle-loading gun has a simpler and stronger construction, but the gun detachment are more exposed than with a breech-loading gun, and if loaded carelessly, the shot may not be rammed *home*, in which case the metal of the gun may be fractured by the suddenly condensed gas.

Systems of Rifling.

I will now say a few words on the different systems of rifling. In what does a *system of rifling* consist? Essentially in the method of giving the rotatory motion to the projectile. This definition will not satisfy some inventors, who wish to claim a particular *twist* as a part of their *system of rifling*. It would, however, be quite as reasonable to claim a particular charge. The rotatory motion, as you all know, is given to prevent the projectile from turning over in flight; and the velocity of rotation required depends upon the form, length, and weight of the projectile, no matter what the system of rifling may be; in fact, the number of revolutions made by a shot $= \frac{\text{I. V.}}{\text{length of twist}}$, and therefore, with the same charge, the same twist must be obviously necessary.*

A twist, like a charge, may suit a particular rifled gun, but this is quite another thing. A *gaining twist* is advantageous, for, by employing it, the initial strain upon the gun is reduced, the rotatory motion not being given when the shot is set in motion, but gradually acquired as it moves down the bore. It is better to give rather more twist than is required under ordinary circumstances at the expense of a little extra strain; for should the twist be merely sufficient to impart the necessary rotatory motion with the service charge, the velocity of rotation will probably be too low with a reduced charge to keep the projectile steady in flight.†

The diameter of the bore has also been often mixed up with the system of rifling, with which it can have nothing whatever to do. As the diameter is decreased, so will an elongated projectile oppose a less surface (in proportion to its weight) to the resistance of the air, or of that of the substance fired at; but, on the other hand, it will expose a less area to the force of the gas, and will, therefore, have a lower initial velocity; it will have less capacity as a shell; its cartridge must be elongated, thereby throwing the strain forward, the amount of powder that can be usefully employed will be less, and if the length of the bore be not increased, the expansion of the gas will be more limited. This question has been discussed in this room, and should be now thoroughly understood. In the table, p. 221, the loss of initial velocity by decrease in the size of the bore is clearly shown:—

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* The I. V. is very little affected by the system of rifling.

† This was practically shewn by the inaccurate practice of the 600-pr., when fired with a small charge.

Ordnance.	Charge.	Projectile.		Initial velocity.
		Weight.	Diameter.	
	lbs.	lbs.	in.	
Britten's (32-pr. rifled)	5	50·36	6·24	1209
Armstrong's 40-pr.	...	41·25	4.75	1197
" 3-grooved shunt	9	68·40	6·4	1283
Whitworth's 70-pr.	...	68·56	5·5 / 5	1132
Armstrong's 70-pr.	10	74·60	6·4	1271
Whitworth's 70-pr.	...	68·56	5·5 / 5	1199

Mr Whitworth and his admirers have constantly asserted that his small-bore gives a flatter trajectory than the larger bores chosen by Armstrong, Britten, and others. This is, however, not the case under all circumstances, and arose partly from the fact of the Whitworth guns first tried, being fired with charges of $\frac{1}{6}$ of the weight of the projectile, whereas the greater number of other rifled guns used charges of only $\frac{1}{8}$ or $\frac{1}{10}$. Mr Whitworth is quite right to use as large a charge as he can, but this must be taken into account in drawing comparisons. In practice from two rifled guns of different calibres, but firing projectiles of the same weight with equal charges, the large bore will give a lower trajectory for a short range than the small bore, but at long ranges the small bore will give the lower trajectory. For the larger bore will give the higher I.V., and therefore up to a certain range the lower trajectory; but as the projectile with the smaller diameter is less retarded, its trajectory will gradually become lower, as compared with the other, until beyond a certain range the smaller bore will give the lower trajectory. Small bores have found little favour on the continent, and it is for the authorities to demand either a large or a small bore, as circumstances may require.

The following conditions are requisite in any rifled gun to ensure accuracy of fire:—a rotatory motion must be given to the projectile round an axis parallel to, or coincident with, that of the bore; the axis of the shot must be stable on leaving the bore; and the velocity of rotation imparted to the projectile must be sufficient to counteract the pressure of the air tending to turn the shot over or render it unsteady in flight.

Great numbers of rifled guns with projectiles to correspond have been proposed, but most of the *systems* of rifling that have been adopted by any service, or tried on the practice-ground, may be divided into the following classes:—

(1) Muzzle or breech-loading guns having projectiles of iron fitting the peculiar form of the bore mechanically.

(2) Muzzle-loading guns, with projectiles having soft metal studs, or ribs to fit the grooves.

(3) Muzzle-loading guns, with projectiles having a soft metal envelope, coating, or cup, which is expanded by the gas in the bore,

(4) Breech-loading guns, with projectiles having a soft metal coating larger in diameter than the bore, but which is compressed by the gas to the form of the bore.

I shall only give types of each class, for there will be no occasion to explain the different systems, which have been so fully described by Captains Scott and Fishbourne.

The Whitworth and Lancaster systems may be taken as examples of the 1st class.* The great advantage shared by both is, that the projectile is made of only one metal; but as this must be iron, a steel bore is indispensable. Unless both bore and projectile are turned with great accuracy, and cleared from rust or dirt, the projectile may jam in loading—a very serious objection, for in the heat of action the gun might be fired when the shot was not home, and thus be burst. Mr Whitworth has very ingeniously modified the hexagonal form, so as to facilitate the loading, and if enough windage be allowed, difficulty in loading will not probably be experienced; as, however, the windage is increased, the fire will be less accurate, and the bore will suffer more wear. The hexagonal form is unfavourable as regards capacity of shell, and as the projectile is made of hard metal, the *gaining twist* cannot be employed either in a Lancaster or Whitworth gun. In the Lancaster there is a much greater tendency to jam than in the Whitworth system.

The French, shunt, and Scott's systems belong to the 2nd class. In all, the shot is centred so as to ensure stability of axis, there is no difficulty of loading, and, as the driving sides of the studs or ribs can be made of soft metal, the wear of the grooves is much reduced, so that either iron or steel may be used for the bore. By placing on the shot smaller studs in front than behind, a gaining twist may be employed.

Bashley Britten's system is a fair example of the 3rd class; it possesses several important advantages, viz. easy loading, accuracy of fire, and but little wear of the grooves; but the projectiles will not bear large charges, the expanding envelope giving way. Parrott's and Blakely's systems are nearly similar in principle.

The Armstrong and Prussian B.L. systems belong to the 4th class. With these the bore can be readily cleaned, the loading can be easily performed, in the smaller natures of guns at least, and the soft coating does not injure the bore. The chief disadvantage is the great initial strain due to the necessity of the compression of the lead coating.

The system of rifling is not, after all, of such very great importance; good results, as regards accuracy of fire, may, doubtless, be obtained with most of them, if both guns and projectiles are manufactured with equal skill and care.

Ordnance of different Services.

I will now endeavour to compare British with Foreign ordnance, and I think I shall be able to show that our condition is not quite so hopeless as has been represented, but rather the reverse. I shall not allude to the S.B.

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* Lancaster now has a few copper steadying studs to facilitate loading.

cast-iron or bronze ordnance, with the capabilities of which we are all well acquainted. I will take the different natures of guns in the following order :—

Field guns (including position pieces),
Siege and garrison guns,
Naval and coast battery guns.

It is now pretty generally acknowledged that rifled ordnance should be used in preference to S. B. guns for land service. The English, Americans, French, Prussians, and other leading powers, are supplied with rifled guns both for field and siege service; a proportion of S.B. pieces may be retained, but chiefly with a view to economy. In the late American campaigns considerable numbers of S.B. guns were employed by both sides, but this may be easily accounted for; the country is so densely wooded that case-shot ranges are frequently the only ones practicable, and, no doubt, both sides were obliged to use any guns that they could procure.

You are all aware that the advantages gained by substituting rifled for S.B. guns, are

Increased accuracy of fire,
Destructive effects at greater ranges,
Capacity of shell.

The two latter being due to the elongated forms of the projectiles fired from rifled guns.

By placing the weights of projectiles, the proportional charges, and the bursting charges of the shells, of different field guns in a table, the relative values of the latter as weapons may be compared.

Rifled Field Guns.

Nature of gun.	Weight of gun.	Charge.	Projectiles.						Remarks.
			Shrapnel or segment.		Common shell.				
					Weight.		Burster.		
British :—	cwt.		lbs.	oz.	lbs.	oz.	lbs.	oz.	
20-pr.	16	$\frac{1}{8}$	19	10	20	8	1	0	
12-pr.	8	"	10	8					
9-pr.	6	"	8	5					
French :—									
Canon de 12	12	$\frac{1}{10}$			25	4	1	1	
" 4	$6\frac{1}{2}$	"	11	7	8	12	0	7	
American :—									
20-pr.	$15\frac{1}{2}$	$\frac{1}{10}$	19	8	18	12			The weights in the column of shrapnel for American guns are those of solid shot.
10-pr.	8	"	10	8	9	12			
3-in.	$7\frac{1}{2}$	"	10	0	10	0			

The Prussian 12-pr. steel rifled gun weighs rather more than 7 cwt., the charge is $\frac{1}{10}$, and the projectiles weigh about 13 lbs.

For ready comparison I have given the weights of guns in cwts., and the weights of the charges in terms of the weights of their respective projectiles. I have purposely omitted mountain artillery, as, in a short lecture, my remarks must be confined to the most important questions.

The table shows that the projectiles of the different guns differ little in power, the French having a slight advantage; the British, however, are fired with the highest velocities.

	Velocity in feet.
British:—	
20-pr. common shells	1114 per second.
12-pr. segment	1218 "
9-pr. "	1036 "
French:—	
Canon de 12 common shells	1006
" 4 "	1066

The French employ three kinds of projectile, and all experience shows that one projectile will not answer three distinct purposes. Common shells are often required under circumstances where segment shells would be useless; and a case-shot which depends for its action upon the preparation of a fuze is very objectionable; simple case-shot and common shells will probably be introduced into the field-service batteries. In actual warfare our officers have generally kept a number of segment shells with their fuzes prepared for case firing.

As regards precision of fire, I have little hesitation in saying that the practice of our B.L. Armstrong guns is quite as accurate as can be required for any service, and I believe more so than that of most of the foreign guns. I will give you an instance. In the *Aide-Mémoire de Campagne*, of 1864, the mean errors, both in range and direction of projectiles fired from the *canon de* 12, are so eccentric that nothing can be made of them: at 1300 metres the error in range is only about one-sixth of what it is at 400 metres, and at 2050 metres the error in direction is less than it is at 700 metres. The *canon de* 4 appears to be a more accurate gun; the mean errors in range at 1000 and 1800 metres are 22 and 27 metres respectively; those in direction and at the same ranges 1·2 and 2·5 metres. With our B.L. rifled guns the mean errors in range at 1000 and 2000 yards are 19 and 21 yards respectively, and in direction ·8 and 2·1 yards respectively.

The Prussians, like ourselves, employ B.L. guns for field service, the French, Americans, and others, M.L. guns. In the Armstrong B.L. (screw) system, strength has been to some extent sacrificed to easy loading, but notwithstanding the abuse poured down upon both the method of closing the bore and the whole construction of our B.L. field guns, they are perfectly safe and can be readily served; the vent-piece* lasts but a short time compared to the rest of the gun, but should one fail it can be easily replaced by another, and the present form prevents dangerous results.

The Prussian field guns are of Krupp's steel; the French and some other nations have converted their S.B. bronze guns into rifled pieces, thus

* In consequence of its support by the breech-screw being only partial, and the vent being bored through it.

utilizing their old *matériel,* but not obtaining ordnance that will wear like wrought-iron or steel guns. The American 3-inch gun is a solid forging, and as it is so small, the metal is probably sound.

Let us now compare the siege and garrison guns.

Rifled Siege or Garrison Ordnance.

Nature of gun.	Weight of gun.	Charge.	Projectiles.					
			Shot.		Shrapnel or segment.		Common shell.	
							Weight.	Burster.
	cwt.		lbs.	oz.	lbs.	oz.	lbs. oz.	lbs. oz.
British :—								
B.L. 7-in. (heavy)	81	$\frac{1}{8}$	90	0	98	0	83 12	6 4
do. (light)	73	$\frac{1}{10}$	90	0	98	0	83 12	6 4
M. L. 64-pr.	65	$\frac{1}{8}$	64	0	62	10	60 0	4 8
B.L. do. (wedge)	$61\frac{3}{4}$	"	64	0	61	14	60 0	4 4
B.L. 40-pr....	35 / $32\frac{1}{2}$	"	41	3	39	0	38 5	2 8
American:—								
100-pr. ...	$86\frac{1}{2}$	$\frac{1}{7}$ to $\frac{1}{10}$	70 / 100	0 / 0	...		100 0	*
30-pr. ...	$37\frac{1}{2}$	$\frac{1}{10}$	30	0	...		25 0	†
French	56	$\frac{1}{9}$ to $\frac{1}{13}$	60 / 100	0 / 0	...		...	...
Spanish	62	$\frac{1}{9}$	61	0	...		...	...
Prussian ...	$51\frac{1}{2}$	$\frac{1}{12}$	76	8	...		59 13	2 0

As our guns are of wrought-iron, but those of the Americans, French, and Spaniards are merely hooped cast-iron guns,‡ there can be but little question as to which would prove the safer and more enduring pieces. The Prussian gun in the table is a bronze gun, but they have also some steel pieces. The formidable effects produced by the shells of the 40-pr. and 7-inch guns (owing to their large bursting charges) have been amply shewn in our own experiments. The 7-inch guns were intended as naval pieces, and their

* Burster about 8 lbs.

† Burster rather over 1 lb.

‡ American, hooped with wrought-iron; French and Spanish with steel.

fire would be most formidable against wooden ships, for which purpose they were constructed; they are mere shell guns, and undoubtedly the worst Sir W. Armstrong made; but it must be remembered that they were introduced without proper experiments, when there was a great pressure for rifled guns, and when it was erroneously considered that guns should be made as light as possible. The B.L. screw system cannot be applied with advantage to guns of such a size, unless the charges are very small; with large charges, if the vent-piece is sufficiently thick, it is too heavy to handle conveniently. But the 64-pr. and the 40-pr. are excellent guns.

We come now to the ordnance required for ships of war and coast batteries, which must be constructed to bear very large charges of powder and heavy projectiles, so that their fire may prove destructive to iron-plated vessels; an object some people seem to imagine the only legitimate one left to artillery of the present day.

It will be sufficient for our purpose to compare the heavy British ordnance with those of the Americans, for other nations have done little or nothing in the manufacture of guns throwing projectiles over 100 lbs. in weight. We sometimes hear mysterious rumours of monster guns supplied to foreign governments, but as they are also said to have been made in this country, we need not be alarmed. In fact, as we publish the results of our experiments, we cannot be surprised if other nations wait, perhaps wisely, until a certain amount of success has been obtained in the manufacture of large guns, and that while thus saving their money, they will be enabled to start at once with good materials and tried constructions. Of this, however, we may be certain, that whatever power possesses the best guns at the commencement of a war will have a great advantage over others not so well provided; although such pieces cannot for long be confined to any one particular service.

In the table I have only given the American S.B. ordnance. The United States have also two large rifled guns.*

Gun.	Projectile.	Charge.
8-inch	175 lbs.	16 lbs.
10-inch	250 lbs.	25 lbs.

But as they are hooped cast-iron ordnance, they failed, as might have been expected; and after six had burst in the federal fleet, while bombarding Fort Fisher, and 44 men were killed, they were condemned in the strongest terms as unsafe by the admiral.

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* They have also a few Blakely and other rifled guns, but the Parrott rifled guns are alone recognized in their latest official tables.

British M.L. Built-up Ordnance.

Gun.			Projectile.	
Nature.	Weight.	Charge.	Weight.	Burster.
	tons.	lbs.	lbs.	lbs.
Rifled. 13·3″ (600-pr.) ...	23	70	Steel shot ... ... 603 „ shell ... ... 585 Cast-iron do 554	24 42½
Rifled. 10·5″ (300-pr.) ...	12	35	Steel shot ... ... 301 „ shell 297	15
Rifled. 9·2″	12	43 30	Steel shot ... ... 221 „ shell ... ... 206 Cast-iron do 232	11 18
Rifled. 7·″ L.S.	7	22 14	Steel shot ... ... 100 Cast-iron do ... ... 100 Cast-iron shell... ... 106¾	8¼
Rifled. 7·″ N.S.	6½	22 14	do	
Rifled. 64-pr.	3¼	8	Cast-iron shot ... ... 63½ „ shell 60	4½
S.B. 150-pr.	12	40 35 20	Steel shot ... ... 168 Cast-iron do ... ... 150 „ shell... ... 104	6⅛
S.B. 100-pr.	6	25 20 12	Steel shot ... ... Cast-iron do. ... ... 94 „ shell... ... 66	

S.B. Cast-iron American Ordnance.

Gun.	Weight of gun.	Charge.		Weight of shot.	Weight of shell.	Bursting charge of shell.
		Service.	Minimum.			
	tons.	lbs.	lbs.	lbs.	lbs.	lbs.
20-in. L.S.	51·42	100	...	1000		
do N.S.	44·64	100	...	1000		
15-in. L.S.	21·91	50	...	440	330	17
do N.S.	18·75	35	60	400		
13-in. L.S.	14·61	30	...	300	224	7
do N.S.	16·07	40	...	280	224	
11-in. N.S.	7·14	15	20	170	130	
10-in. L.S.	6·72	15 shell 18 shot	...	127½	100	3
do N.S.	5·35	12½	16	125	100	
do N.S. (or 125-pr.)	7·36	40	...	125	100	

All cast hollow, except the 10-in. of 5·35 tons.

All shell guns except 10-in. 125-pr.

20-in gun only, at present, experimental.

Solid shot are only to be fired from the 15-in. N.S. gun at iron-clad vessels, and then with 50 lbs.; 20 rounds may, however, be fired with 60 lbs.

The S.B. guns are formidable weapons, although they are merely cast-iron shell guns. The 20-inch gun is at present only an experimental piece; and I think we may safely conclude that for some time to come there will be very few of them, and the few that may be made will be very cautiously used. The bursting of the 15 or 13-inch gun would probably completely paralyze a ship's crew, and destroy all confidence in these pieces. Our guns being made of wrought-iron will not, on failure, break up like cast-iron or steel ordnance; and from their accuracy of fire, the capacity of their shells, and the power these latter have of maintaining a comparatively high velocity (in consequence of their elongated form), the British are in all probability greatly superior as weapons to the American guns.

One of the most important questions at the present time is this, Are monster guns required? Opinions are divided; but let us turn to facts, and see what has been done. I have endeavoured, in the following table, to arrange some of the leading facts in order, so as to give an idea (necessarily a rough one) of the projectiles and charges requisite to actually penetrate certain structures at different ranges. I have not chosen the targets in preference to any others, but simply believing that they represent the average resistance offered by sea-going vessels, and also for convenience of comparison.

Target penetrated by Steel Elongated Projectiles.

Range.	Weight of gun.	Projectile.		Charge.	Target.
		Nature.	Diameter.		
yds.	cwt.	lbs.	in.	lbs.	
200	8	12 shot	3	1¾	2½″ iron plate.
〃	〃	12 shell	〃	〃	〃 and 12″ wood backing.
〃	81	110 shot	7	12	5½″ iron plate.
〃	134	104 〃	〃	25	"Warrior."
600	148	130 〃	6·4	25	〃
800	tons.	130 〃	〃	27	〃
1500*	12	221 〃	9·2	44	"Small plate." ‡
〃 †	〃	301 〃	10·5	45	〃
2000	22	610 shell	13	70	"Warrior."

It appears then, from what has been already accomplished, that there is at present no occasion to employ monster ordnance for the destruction of ordinary plated vessels. The guns we are now making, which will throw projectiles of 200 or 300 lbs. weight, with charges of 45 lbs., are, if properly used, which no doubt they will be, quite sufficient for the purpose. Further than this, however, it is probable that few iron-plated sea-going vessels (now afloat) could withstand the fire of our rifled 7″ guns of 130

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* Ascertained for this range by using a 30-lbs. charge at 200 yards.

† do. do. 35 lbs. do.

‡ 5½ inches of iron and 27″ of wood; the wood and iron not disposed in such an advantageous manner for resistance as in the "Warrior" target.

cwt., fired with 25 lb. charges, at 800 or even 1000 yards range;* for we must remember that, in actual warfare, vessels are constantly subjected to a continuous fire, and not merely to a few blows delivered at certain intervals of time; and, that a structure may thus be kept in a constant state of vibration by the repeated impacts of shot, and will offer less resistance than when time is allowed, between the rounds, for the metal of the armour to resume its former condition of repose. We should also remember that the few plates upon which experiments are usually made are in all probability of sounder construction than those produced in quantities for the plating of several vessels; also, that when a ship has been for some time at sea, and may in addition have been in action, the armour (bolt plates and fastenings) will have been subjected to many shocks and strains, and will, therefore, have been considerably weakened.

I may here remark that Mr Whitworth deserves great credit for showing that more might be accomplished against iron plates, by employing rifled guns of moderate weight and hard projectiles, than by firing at them with a rude monster like the Horsfall gun, with the much-vaunted round ball; also for proving that iron plates could be pierced by shells, at that time considered next to an impossibility. It is now probable that we shall not be compelled to use steel for our projectiles; the *chilled* iron shot proposed by Major Palliser giving promise of success.

For the destruction of floating batteries, monster guns would certainly be required, but may not be procurable, as such batteries could be made practically invulnerable. For naval actions S.B. guns may be necessary; but it is easy to choose a system of rifling which admits of both spherical and elongated projectiles being fired from the same gun. I will, however, venture to say that rifled guns that will bear a charge of $\frac{1}{5}$ † will answer every purpose.

I might have been expected to allude to the late Armstrong and Whitworth experiments, but I have purposely avoided doing so, for I never could see that any object would be gained by them, except the probable satisfaction (or rather increased dissatisfaction) of two rival manufacturing firms and their respective adherents. Whatever the report may be, I cannot believe it will satisfy the officers of Her Majesty's service.

As far as my branch of the service is concerned (for I will not presume to say what course should be taken with naval armaments), the government has ample means of obtaining the best information and advice on a purely artillery question (the respective merits of two guns) from a regularly constituted committee, a school of gunnery, and a director-general of ordnance, besides many artillery officers of high rank and great experience, who hold responsible positions in or near London. Then why ignore these, and appoint a mixed committee, many of the members of which can know

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* The result of a recent experiment shows "that a structure such as the 'Warrior' can be penetrated at 200 yards range with elongated shot and shot cast in chill, when the form of the head of the latter is elliptical, fired from a 7″ rifled gun with $\frac{1}{4}$ charges;" and the report adds, "but it is probable that had the 7″ steel shot been elliptical headed, instead of hemispherical headed, penetration would also be effected at the longer range" (1200 yards).

† $\frac{1}{4}$ has lately been fired with success. The larger the gun, however, the less must be the proportional charge.

nothing whatever concerning the requirements of the service? As for the artillery and naval officers on it, a better selection could not probably have been made; and I would not say a word against any of the other members, who are all able men, and have no doubt done their best to obtain true results. But the decision upon a mere artillery question should not be left to a mixed committee.

Purely scientific experiments* are often better left to committees composed of officers and well-known men of science, but these should not be mixed up in any way with trials of guns, carriages, or other *matériel.*

John Bull must learn patience, and not expect to re-model his artillery in a year or two; and he should also turn a deaf ear to the loud and positive declamations of amateurs, and trust all questions of armament to those who are educated for and spend their lives in the service. Those who propose valuable inventions, and still more those who spend time, thought, and money in carrying them out, deserve our gratitude, and should be amply rewarded by government, but they should not therefore be constituted judges of other inventions, or, unless officers of experience, be taken as authorities on military or naval questions.

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* To ascertain the laws of resistance of the air, or those of different materials to the impact of projectiles, &c., or the suitability of any substance (as gun-cotton) to military purposes.

PALLISER'S (CHILLED) SHOT AND SHELL.

BY CAPTAIN VIVIAN DERING MAJENDIE, R.A.

ASSISTANT SUPERINTENDENT, ROYAL LABORATORY.

Chilled projectiles have attracted considerable attention since they were first brought forward in 1863, by Major (then Captain) Palliser, of the 18th Hussars; but they have lately derived additional interest and importance from the remarkable results which have attended the more recent experiments, and from the fact that they are now definitely adopted for battering purposes.*

The following paper, in which the origin, nature, and practical value of chilled projectiles are discussed, has been drawn up with a view to replying to the various enquiries which have been addressed to me on the subject, and of satisfying further enquiry by anticipation.

The different character of castings obtained from sand and metallic moulds, respectively, has long been known; and is thus explained by Dr Percy in a passage quoted by Captain Harrison in a former No. of these "Proceedings."† "The mode of existence of carbon in iron is in great measure determined by the conditions of solidification after complete fusion, and the temperature at which fusion has been effected. Rapid solidification favours the retention of carbon in the combined state, and by this means it is possible to convert characteristic grey-iron into perfectly white iron. Thus by pouring liquid grey cast-iron into a cold metallic mould, so as to cause the most sudden cooling possible the exterior of the solid iron, where it comes in direct contact with the mould, will be found to be in the state of white iron, while the interior will be in the state of grey-iron. This principle is extensively employed in practice, in the process known as *chill-casting*. It is adopted when it is desirable to render the surfaces extremely hard, white iron being intensely hard, as compared with grey-iron." To this passage I would draw particular attention, for it contains the *rationale* of "chill-casting" or "case-hardening;" further calling attention to the fact that white iron, which is not *normal* cast-iron, but to a certain extent an exceptional product of the furnace, differs chemically from grey or "foundry" iron principally in the condition of the carbon which it contains: in white iron, the carbon is in a combined state; in grey iron it is generally uncombined, being mechanically diffused through the mass in the form of graphite, the amount of carbon not *necessarily* differing materially in either.

* W. O. Letter, 26th October, 1866, $\frac{75}{2624}$ intimated, "the adoption of chilled iron as the material for projectiles required in the service for battering purposes."

† Vol. IV. p. 202.

We have thus in connexion with chill-casting, these data: 1st, That white iron contains its carbon chiefly in a combined state; 2nd, That iron so constituted is intensely hard as compared with grey iron, in which the carbon exists chiefly as graphite; 3rd, That rapid solidification, such as chill-casting, "favours the retention of carbon in the combined state," and thus tends to harden and alter the character of the iron.

The process of chill-casting is and has long been perfectly well known in the iron trade, being usefully employed for many purposes, such, for example, as the surface-hardening of those portions of machines or articles in which great hardness is required.* Moreover, owing to certain mechanical advantages which the process is sometimes found to possess, and to the comparative cheapness with which by means of it certain articles can be produced, it is frequently employed where surface hardness is not specially sought for—"as, for example, with railway chairs, when large numbers are to be produced of identical dimensions."† For similar reasons shot were so cast for many years,‡ and to this day, although the necessity for the distinction has long passed away, the nomenclature of "shot cast in sand," or "sand shot," is retained for those small round shot used for making up case and grape, which were alone cast in sand moulds at a time when the higher natures were cast in chills.

But here it is necessary emphatically to explain that the shot cast in chills of that period were very different projectiles from the chilled shot of the present day. It is important clearly and thoroughly to grasp the distinction, first, because such a distinction involves the recognition of Major Palliser's claim to originality in the production of a particular projectile for penetrative purposes; and, secondly, because it is difficult otherwise to appreciate the characteristic construction of this particular projectile.

The shot cast in chills were, as we have seen, so cast *for manufacturing reasons only*, and without reference to the qualities or intended uses of the projectiles thus produced. The origin of the chilled shot, on the other hand, Major Palliser tells us, was as follows:—"At the time I first heard of Mr Whitworth's tempered steel shot, I conjectured that the results he obtained were to be attributed as much to the hardness, as to the toughness and tenacity of the material he employed. I had previously noticed in some experiments that I had made in casting iron round wrought iron tubes, that, under certain conditions, the cast-iron was rendered very hard and unyielding where it came into contact with the cold wrought-iron. I was aware that cast-iron would resist a far greater crushing force than wrought-iron could, and putting these facts together, I thought it highly probable that if I cast an iron shot in a mould which would rapidly carry off the heat by conduction, and if, at the same time, I made the fore part of the shot of such a form as would convert the sudden shock of impact

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* "All sorts of articles in which hardness of surface was a desideratum, have been cast in chills for years, if not centuries. The Messrs Ransome turn out hundreds of tons of chilled ploughshares annually."—*Mechanics Magazine*, August 26th, 1864.

† Letter of Mr Alexander to Mechanics' Magazine, July, 1864.

‡ During the great French war, at the close of the last, and the beginning of the present century, the system of chill-casting shot prevailed in England. Before that, sand and sand loam had been used. Subsequently sand was reverted to.

as much as possible into a uniformly increasing pressure, the brittle nature of the material would not be of much consequence."*

As regards the distinctive features of the two projectiles, we know from extensive experience with shot cast in chill, and returned from out stations and abroad to be broken up, that in the majority of cases the chilled effect was sensible only to a very small and uncertain depth; that, in fact, the shot were generally only more or less surface, or case-hardened. Major Palliser's chilled shot, on the other hand, have a uniform and characteristic structure. A section of one of these shot exhibits chilling effects through and through, in some cases the actual centre of the shot being allowed to shade off into grey iron.† A perfectly definite result is thus always aimed at, and can, with little difficulty be obtained, and herein, as will presently appear, lies one of the advantages of chilled projectiles.

Here, then, we have an important and characteristic distinction between shot cast in chill and chilled shot. The former have an uncertain fracture, in which grey iron more or less predominates, in which, indeed, in some cases, white iron is scarcely discoverable; the latter have a fracture of almost unvarying uniformity—a fracture in which grey iron is scarcely perceptible, and from which, in recent castings, it has been altogether eliminated. The one, in fact, was a mass of iron which from an accident, as we may express it, in manufacture had become externally hardened to a greater or less extent; the other is a mass of iron designedly made for a particular purpose, of a definite and carefully determined hardness and structure throughout. We have next to examine the causes of this remarkable difference in projectiles, the processes of manufacture of which so closely resembled one another; and we here touch still more nearly Major Palliser's claims to originality. When shot were cast in chill for the convenience or benefit solely of the manufacturer, the character of the iron employed was little studied; but in the Palliser projectiles, where not the manufacturer's but the artilleryman's interests are studied, this is a point of foremost importance. Extensive experiments have clearly established not only that certain irons will scarcely chill at all,‡ but have pointed out exactly what those irons are, and have supplied perfectly definite and reasonable results respecting the fractures and characteristics of a variety of irons and mixtures of irons treated by the chilling process. By the light of these experiments we now know almost to the fraction of an inch the depth to which the various brands of grey iron may be chilled; while we have discovered, on the other hand, that it is possible to use *too* hard an iron—an iron so hard that it will be liable to "over chill," and crack in cooling. It is between the extremes indicated by these data that if we would produce a serviceable chilled shot, the mean must be struck; and this

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* Letter to Mechanics' Magazine, July 21st, 1864.

† The only object of making the shot slightly grey in the centre is as a check, to prevent the manufacturer erring on the side of excessive hardness. For a long time this check was always employed, but recent experiments have seemed to indicate the desirability of chilling right through.

‡ Indeed, it is stated on good authority, that some grey irons will not chill at all: "Not *all* grey iron can be converted into white by this means."—Percy's *Metallurgy*, p. 117. See *Ibid.* for experiment establishing this fact.

mean is generally found either in a mixture of white and grey cold blast* irons in proportions which will vary slightly according to the size of the projectiles and the brand of the iron, or in the employment wholly of "mottled" iron—an iron which falls about mid-way as regards its chemical characteristics, between white and grey iron, containing about half its carbon in a combined, and the other half in an uncombined state; and which may, in fact, be regarded as white and grey iron *ready mixed*.* Further than this it is unnecessary, indeed, it would be difficult and perhaps undesirable, to detail the precise mixtures or natures of iron employed by Major Palliser for his projectiles. Suffice it to say that while these mixtures or natures are now carefully selected with reference to the particular object in view, and by the light of the experiments above referred to, no such selection was ever made in the case of shot cast in chill, when ordinary grey or the cheapest available irons were commonly employed.

It follows, then, from what has been stated, that neither in their origin, in their object, or in their nature did the shot cast in chill of half a century ago resemble the chilled shot proposed and perfected by Major Palliser, whose claim to originality in the production of a shot of superior penetrative powers may therefore be fully conceded.

Nor do Major Palliser's claims to originality in the production of these projectiles cease here. A reference to the passage above quoted, in which he describes the origin of his chilled shot, will shew that the problem which he set himself to solve was two-fold:—1st, to produce a shot of great hardness, as compared with ordinary cast or wrought-iron, and 2nd, "to make the fore part of the shot of such a form as would convert the sudden shock of impact as much as possible into a uniformly increasing pressure, when the brittle nature of the material would not be of much consequence." In other words, the form of the shot must be such as to neutralize the inevitable brittleness of the material. The form of head of chilled shot is therefore a matter of scarcely less importance than the iron of which it is composed.

No subject has probably provoked more discussion than this one, of the form of head best suited for penetrative purposes, and on no subject have more opposite opinions from time to time been advocated and received. For some time a flat-headed shot was thought to be the most serviceable, and this view was strongly advocated by Mr Whitworth. The experiments

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* Cold blast irons have been used, not merely because they generally take the chills better than hot blast irons, but because their superior strength seems to render them more suitable for the purpose. There are, however, grounds for hoping that certain brands of hot blast irons, or of old iron, in the form of condemned stores, &c., may be usefully employed to a considerable extent. This will effect a material cheapening in the manufacture, and be an important point in favour of the projectiles.

† The following analysis of samples of grey, mottled, and white irons exhibit very clearly the conditions and quantities of carbon contained in each nature:

	Combined carbon p.c.	Uncombined carbon p.c. (graphite.)
Grey ...	1·02	2·64
Mottled ...	1·79	1·11
White ...	2·46	0·87

For these analyses, together with some other information embodied in this paper, I am indebted to a lecture delivered by Mr Bloxam, Professor of Chemistry, in 1865, to the "Advanced Class" of Artillery Officers.

made by the Special Committee on Iron in 1862-3, inclined the committee to prefer a conical ended* or round-ended shot to one with a flat head, alike for range, accuracy and penetration;† with a reservation as to the possible superiority of flat heads for oblique firing.

Some time in 1862, Major Palliser had arrived, by means of a series of independent experiments, at a conclusion from which he has never since swerved, viz.: that the only form of head which would convert the shock of impact into a gradually increasing pressure sufficient to neutralize the brittleness of the material was an elongated pointed head. Such a form of head admits obviously of many modifications, of which the more important are included in Major Palliser's specification.‡ A conical head, for example, is "an elongated pointed head," (Fig. 1); so is a conoidal or pointed ogival head, (see Figs. 2 and 3); and so is a combination of the ogival and the cone, (Fig. 4). The latter form is embodied in the so-called

Fig. 1.

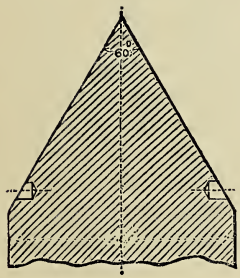


Fig. 2,

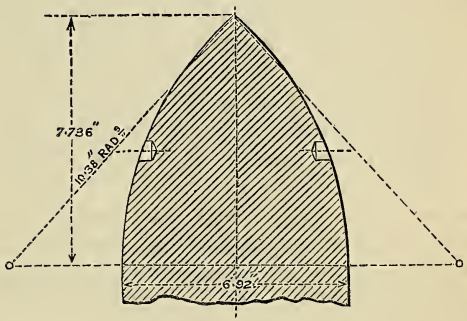


Fig. 3.

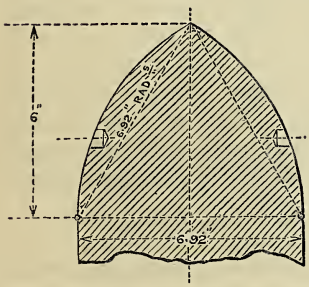
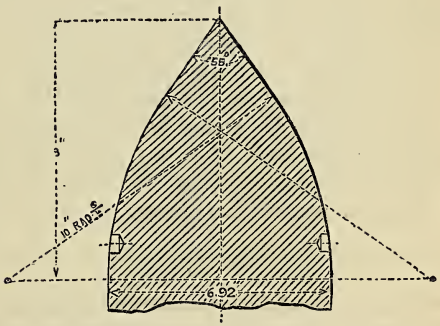


Fig. 4.

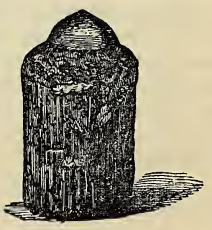


* The conical ended shot referred to, were of a form proposed by Mr Makin, viz.: a cylinder, from the centre of the end of which projected a conical or conoidal end.—"Proceedings," Royal Artillery Institution, Vol. IV. p. 214.

The shoulders being found to be an impediment, were subsequently removed.

† "Proceedings," Royal Artillery Institution, Vol. IV., pp. 214-15.

‡ Specification, No. 1334.



"Prussian" head, for which at one time the Ordnance Select Committee were inclined to express some preference, but which subsequent experiments appear to shew is not as effective for penetrative purposes as the ogival head. The first chilled shot made by Major Palliser, in 1863, had ogival heads, struck with a radius equal to one and a quarter diameter of the projectile and brought to a point, and no good results have ever been obtained with chilled shot having a more obtuse head than one diameter. A number of experiments have, however, been made with more pointed ogival heads; and the best results with shells have been obtained with pointed ogival heads struck with a radius equal to $1\frac{1}{2}$ diameter of the projectiles (Fig. 2).*

There are good reasons for supposing that the forms of head which have been adopted for the Palliser projectiles, viz. for shot radius=1 diameter, for shell $r = 1\frac{1}{2}$ diameter, are calculated to give a great amount of general efficiency, regard being had to range, accuracy, and penetration. But if subsequent experiments should suggest further slight modifications, it seems improbable that the limits which we have assigned in the two directions, viz. 1 diameter and $1\frac{1}{2}$ diameter ogival heads will be exceeded.† It is at any rate quite certain that *an elongated pointed head* of some sort is necessary to develope the full effects of the chilled iron—that, indeed, with bluff or flat heads, projectiles of this material are comparatively useless.

From these remarks it will be evident that Major Palliser's invention amounts not merely to a revival of an old practice, nor even merely to the extension of a superficial transformation or hardening, to the centre of the mass, by the employment of carefully selected irons, nor simply to the employment of hard iron, but that it consists in a particular combination of form and material, of head and hardness, upon which the character and efficiency of the projectile depend.‡

It is only comparatively recently that any attempt has been made to employ chilled iron for shell purposes; but the experiments which took place in September and October last at Shoeburyness, shewed that this material, in combination with the pointed form of head, could be thus used with enormous success; and Palliser's chilled shell have now been adopted.

There now only remain to be noticed the advantages which chilled projectiles possess over steel for penetrative purposes. They are four, viz.:—
1. Great saving of expense. 2. Greater uniformity of hardness and structure. 3. Superior penetrative effects. 4. Greatly increased effects after penetration.

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* This form of head closely resembles that proposed by Sir Isaac Newton in his *Principia*, "for a form of body which would in passing through a fluid, experience less resistance than a body of equal magnitude, and of any other shape."—Major Owen's *Motion of Projectiles*, p. 16.

† A more pointed head than $1\frac{1}{2}$ diameter seems liable to snap off on an inclined plate.

‡ In the case of *spherical* chilled shot, which obviously do not admit of the application of a particular form, and the effects of which are thus very much more limited, Major Palliser has disclaimed any desire that these projectiles should be called by his name, as they cannot embody that *combination* upon which his claims in their most complete sense are based. But the merit of spherical chilled shot undoubtedly does belong to Major Palliser, as being the first, according to my shewing in the former part of this paper, who deliberately proposed and carefully systematized the employment of chilled iron for penetrative purposes. The brittleness of the spherical chilled shot is obviated in a measure by making them somewhat tougher than the elongated shot.

1. *Saving of expense.*—It is very difficult to estimate what this will amount to, owing to the manufacture of the steel and chilled projectiles not having yet been established on a sufficiently large or regular scale.* But so far as it has gone it has established that the Palliser shell, even if the more costly mixtures of iron be employed, will not cost more than about one-fifth of the steel shell, and the shot not more than about one-third. The difference will, of course, be greater if old iron be utilized for the purpose. This comparison will serve to indicate the probable saving which the adoption of Major Palliser's invention will have effected.

2. *Greater uniformity of hardness and structure.*—The difficulty of tempering large blocks of steel is well known, and this difficulty has been experienced to a very great extent in the manufacture of steel projectiles. Owing to the inequalities of temper, the most confusing and disappointing results have frequently been obtained with steel shell and shot manufactured by the same makers, professedly of the same quality, and prepared to the same pattern. With chilled projectiles the same uncertainty does not prevail. Where particular brands or mixtures of iron are employed, the results will be sufficiently definite; and although the homogeneity and uniformity of chilled projectiles will doubtless be improved as the system of manufacture becomes perfected and better understood, these projectiles have hitherto shewn themselves to be infinitely more reliable than steel, and remarkably uniform in their weights and their results.

3. *Superior penetrative effects.*—The superiority of Major Palliser's projectiles to steel in this respect has been amply established. Reference might be made to a large number of experiments in support of this statement, but the results of the practice at Shoeburyness against the Bellerophon target, and, more conclusive still, the practice of the 13th and 14th September, and the 24th October, 1866, against a target consisting of 8 inches of iron upon 18 inches of teak, and a ¾ inch iron skin, seem to render such reference unnecessary. On these occasions the massive structure was completely penetrated by every Palliser shell with one exception, fired from the 9″ M.L. R. gun, 43 lbs. charge, at 250 yards range.† Steel shot and steel shell of different tempers and with various heads, fired under the same conditions, all failed to penetrate.

4. *The superior effects of chilled shot after penetration* have always been noticed. The shot break up after passing through the target, and form so much langridge or missile matter, the effect of which in the interior of a ship or other defences is very great, and approaches, in the case of a shot, that which is generally obtained only with a shell. Speaking of these projectiles, Captain Harrison remarks, "we obtain the advantage of langridge, which is lost by using steel shot."‡

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* About 2000 steel shell had been manufactured up to the time of their supersession by chilled projectiles.

† The shell which failed to penetrate had a greatly reduced velocity.

‡ "Proceedings," Royal Artillery Institution, Vol. IV. p. 203.

The following letter from Major Palliser bears upon an objection which has been urged against the merits of his invention, that as white iron cast in sand is nearly if not quite as effective as chilled projectiles,* the employment of the chilling process has nothing remarkable in it after all, and is in reality of little or no value.

Major Palliser explains that he was the first to point out that brittleness might be disregarded in a shot if allied to intense hardness and a long pointed head. This is the broad principle which lies at the foundation of his discovery and to the general application of this principle Major Palliser lays claim; shewing, moreover that the proposition was diametrically opposed to received theories at the time he brought it forward. Secondly, he advocated the chilling method of production merely as a cheap and convenient means to an end:—the conversion of grey or mottled iron into white iron by this process being, as he imagines, cheaper and otherwise, for manufacturing reasons, simpler and more advantageous than the casting white iron, *pur et simple*, in sand moulds, or than the application of a refining process, or than the employment of hard brittle steel.

But, lastly, he imposed no restriction upon himself as to the means by which projectiles of the required hardness should be produced; the question of the adoption of any particular method of giving effect to his principle, being, in fact, merely a question of expense, and inclining probably, as has been pointed out, to the chilling process.

Nov. 28, 1866.

My dear Majendie,

Having understood that you are preparing a paper for the Royal Artillery Institution, upon the "Chilled projectiles" which are being manufactured in your Department, I am anxious to inform you that some eighteen months ago Mr Abel, Chemist to the War Department, analyzed some specimens of chilled shot and ascertained that their properties were similar to those of ordinary white iron.

In a private letter I addressed to General Lefroy,† a copy of which he has been kind enough to send me, on the 3rd of June, 1865, I said: "I understand from Mr Abel that chilling iron is simply turning grey iron into white iron."

In another part of the same letter I said: "Whether the shot be made of chilled iron, or of white iron cast in sand or even of excessively hard brittle steel, they will if combined with a long conical head be merely different ways of applying a common principle which I consider I have proved. That my theory was at variance with the general belief at that time is best shewn by the great nicety with which it was thought necessary to temper steel shot; and that the object sought was to make these shot only so hard as to be tough without becoming brittle"

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* Four white iron shot, cast in sand, were fired on 3rd December, 1866, against the *Warrior* target, and gave very good results; but the experiment was not pushed far enough to establish any real comparison of efficiency between white iron shot produced in this way, and white iron shot produced by chilling.

† President Ordnance Select Committee.

The date referred to in the latter sentence was July 21st, 1864, on which day I addressed a letter to the Mechanics' Magazine on the subject of "Chilled shot." The following extract from the Armstrong and Whitworth report, dated August 3, 1865, or just two months after my letter to General Lefroy, shews "that my theory was at variance with the general belief" even "at *that* time," 26th General deduction of Armstrong and Whitworth Committee, page 88,— "That the nature of steel to be used in projectiles is a question of very great importance. In the very limited practice at iron plates, placed at an angle which represents the circumstances under which naval warfare with armour plated ships must in future mainly be carried on, the Committee *particularly noticed the tendency of steel shot to break up on impact. This tendency, and the impossibility of obviating it otherwise than by increased attention to the manufacture and proper tempering of steel* give pressing and immediate importance to the question of that manufacture and to the certainty of quality therein; and the Committee desire to point out that the employment of steel in the fabric of guns will be materially affected both in cost* and otherwise by the far larger inevitable employment of it in projectiles in future naval warfare."

My chief reasons for not advocating the casting of white iron shot in sand, are that the manufacturing advantages afforded by employment of the chilling process for producing white metal shot are so great, and that greater uniformity and efficiency are obtained by the latter process.

I have employed the term "white metal shot," as it is a strictly correct definition of the projectile which I have proposed. The term chilled shot being strictly more applicable to the surface hardened projectiles which have been proposed by the Americans, and Mr Grusen of Magdeburg† for the purpose of penetrating iron plates.

Yours very truly,

WILLIAM PALLISER.

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* The price of steel is quoted in the Committee's Report, from £70 to £90 per ton.

† Mr Grusen in a patent taken out in this country so late as Nov. 2, 1864, p. 3, lines 17, 19, says:—"The *surface* of the projectile is thus chilled in casting, and a steel-like *tenacity* is thereby imparted to it."

The shot submitted to the Ordnance Select Committee by Mr Grusen's agent in Dec. 1865, is a merely surface hardened projectile. It can be seen in the Committee's Model Room.

REMARKS

ON

MILITARY BREECH-LOADING RIFLES, AND THEIR AMMUNITION.

BY CAPTAIN R. W. HAIG, R.A.

The loss of time incurred in loading a muzzle-loading small arm, an objection which was much greater before the introduction of elongated expanding bullets, owing to the necessity that then existed for using a tightly fitting bullet which was difficult to ram down, has led many to attempt the invention of a safe and serviceable breech-loading arm in which this difficulty should be overcome. Many examples of such attempts are to be seen in the Museum of Artillery in the Rotunda, Woolwich, both for rifled and smooth-bored pieces, some of them made so far back as the 17th century.*

Guns commonly known as breech-loaders may be divided into two classes, chamber loaders, and breech loaders proper.

In the chamber loader, the barrel of the muzzle loader may be supposed to be cut in two, a short distance in front of the seat of the bullet. The short piece at the breech end has then to be loaded in the same manner as a muzzle loader, which can be done by hand, without the use of a ramrod. The chamber has then to be placed in position for firing, that is, so that it shall form a continuation to the front part of the barrel, to which it must be made to fit very closely in order that escape of gas may be prevented.

For these purposes various mechanical arrangements have been tried. In some cases the chamber hinges on a trunnion at its breech end as in several Swedish rifles, in others the hinge is in front, and with the great majority some combination of the lever and wedge is used to press the chamber firmly against the barrel when in the firing position.

The best known, and certainly one of the best rifles of this class, is that of Montgomery Storm, an American, the distinguishing characteristic of which is the method of closing the joint between the chamber and barrel so as to prevent escape of gas. This is effected, not by mechanical pressure, but by means of a cylindrical steel thimble fitting into and projecting slightly beyond the mouth of the chamber so as to enter the barrel a short distance, into which it fits easily. On firing the gun the thimble is expanded, and at the same time forced forward against the barrel making a perfectly gas tight joint at both its ends.

* *Vide* Catalogue, p. 82, &c.

All chamber loaders* are fired by means of an ordinary percussion cap and can be loaded with ammunition suitable for muzzle loading cap guns. If, however, they are loaded with loose powder, the time occupied in loading is considerable, and various cartridges have been devised to expedite the loading, but this is the greatest difficulty that such arms have to contend with. The requirements of the cartridge are that it shall be so thin that the fire from a cap will pierce it and reach the powder. It must be entirely consumed by the discharge so that no burning residue is left in the chamber, and it must be strong enough to stand the wear and tear of carriage and handling.

On the whole, gut skin cartridges appear to be most suitable for this kind of rifle, but it is questionable whether they can ever be made in large quantities of sufficient strength to stand the rough usage of military service.

Chamber loaders as a rule take longer to load and fire than other breech-loading rifles, and are unlikely on this account to be adopted as military weapons by any country.

In the breech loader proper the barrel and chamber are in one piece,

The most convenient division into two classes appears to be: (1) Those in which the charge is fired by percussion cap, and (2) those adapted for a cartridge carrying its own means of ignition.

Those of the first class differ among themselves in the manner in which the breech is closed, and in the mechanical arrangement for closing it.

Some trust entirely to the accurate fit of the breech stopper, as in the case of Sharpe's rifle; others, for example, Westley Richards', use a greased wad which driven forcibly back by the explosion expands and effectually closes the joint, Chassepot, and many others, close the breech with a plunger on which there is a washer of india-rubber or soft metal which is forced to expand laterally by the pressure of the gas on the face of the plunger, and thus completely fills the barrel and prevents leakage.

The innumerable mechanical arrangements, levers moving sideways, upwards, downwards, forward, and back, plugs and plungers of all kinds, scarcely admit of classification, although the efficiency of a rifle is in a great measure due to their excellence and simplicity.

The whole of this class as well as the chamber loaders may be dismissed as inapplicable as military arms for the future, the prevailing opinion now being that for this purpose the greatest rapidity of fire possible is to be sought for, a qualification which belongs only to rifles in which the cartridge carries its own igniter.

The simplest classification of rifles adapted for cartridges carrying their own principle of ignition, is to consider them with reference to the particular nature of cartridge employed.

The most numerous class will include nearly all American breech loaders, and a few belonging to this country adapted for the copper cartridge which carries the fulminate in a rim at the base. This cartridge has been adopted

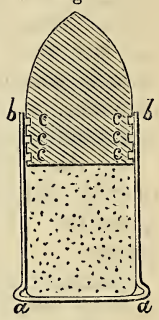
* There is at present an exception to this statement. The Storm rifle has been modified so as to be applicable for a central fire copper cartridge of peculiar construction.

as the military cartridge of the United States, and hence the great variety of rifles which have been produced in that country adapted for its use.

The case of the cartridge is formed of one piece of copper, without joint, pressed into its form by a die.

Fig. 1 is a section of such a cartridge, *a, a* the base with rim into which fulminating powder is distributed by centrifugal motion given to the cartridge case; the copper of the case at *b, b* is swaged into one of the cannelures *ccc* of the bullet, which is thus effectually kept from falling out.

Fig. 1.



The thickness of the copper case, about 0·011″, is such, that when the bullet is in the case, even without powder, the case cannot be bent or distorted by hand pressure.

The lubrication usually employed for these cartridges is pure tallow, or a preparation of stearine.

A cartridge of this kind is not easily injured by wet, and will stand considerable rough usage by reason of the strength of the copper; but it is questionable whether it will remain serviceable for a length of time, subject to such variations of temperature and climate as British service cartridges must be exposed to.

I have seen specimens of these cartridges sent from America, in which while in store the bases of the bullets had become converted into white lead to such an extent as to swell and burst open the copper case and render the cartridge altogether unserviceable, moisture had penetrated through the porous white lead to the gunpowder, and had destroyed its original character.

This corrosion of the bases of the bullets had been produced by the acid matters in the grease used as a lubricant, favoured by the influence of air and moisture.

Most of the rifles adapted for these cartridges have many points of resemblance. The breech mechanism and lock are fitted into an iron frame into one end of which the barrel is screwed, and to the other is fastened the stock. The most ordinary method of opening and closing the breech is by means of a lever which acts also as a trigger guard, and which works on a hinge underneath the barrel. By means of this lever and the mechanism attached to it, not only is the breech opened and closed, but, when opening, the cartridge case of the last round fired is either thrown out clear of the gun, or so far withdrawn that its subsequent removal by hand becomes a simple and rapid operation.

The locks of these rifles resemble in every respect those of ordinary muzzle-loading rifles. The hammer, however, has sometimes a slight projection at the side arranged to strike the rim of the cartridge, or it falls on an intermediate striker, the end of which is in immediate contact with the rim of the cartridge.

The accuracy of fire hitherto attained by these American cartridges in experiments carried on in this country has not been satisfactory, owing doubtless to the insufficiency of the powder in proportion to the weight of the bullet. It would appear that precision at long ranges is not sought for by the American government, but that they are content with moderate accuracy at 500 yards, combined with a less violent recoil than given by the English charge of 2½ drs. powder and 530 grain bullet.

Immediately following the copper cartridge we may consider the Lefaucheux pin cartridge and central fire cartridge of Potet. In both of these cartridges escape of gas at the breech is prevented by a brass capsule which acts in this respect precisely in the same manner as the copper cartridge. Inside this capsule in both cartridges there is a disc of papier-maché about $\frac{1}{4}$ inch thick, which by pressure from within is made to secure the body of the cartridge to the base. In the Lefaucheux cartridge a pin passes laterally through this disc until near the centre where a cavity is made large enough to contain a small copper cap into which the point of the pin projects and keeps it in its place, when in the gun the hammer is so arranged as to strike the outer end of the pin which then fires the cap, and the charge being in immediate contact with it explodes. After firing, the pin is useful in withdrawing the cartridge: the body of the cartridge case is usually made of paper folded round and round and glued together, the thickness being that of stout card.

Very few rifles have been invented adapted for the pin cartridge although it is in most extensive use in this country as a sporting cartridge for shot guns. Its chief objections are liability to explode by an accidental blow on the pin, which is much exposed, and loss of time in loading, as compared with a rim fire or central fire cartridge, by reason of the necessity for placing it in one particular position in the chamber with the pin uppermost.

Fig. 2 shews a section of a pin cartridge, *a* the brass capsule, *b* the papier-maché disc, *c* the pin, *d* the copper cap, and *e* the paper case. Any form of bullet may be used, and no special form need therefore be described.

The central fire cartridge, originally invented by Potet, deserves especial notice, as a modification of it devised by Colonel Boxer, and known as the Boxer cartridge, has been introduced into the service for use with Snider's B.L. converted Enfield rifles.

The construction of the body of the cartridge before the insertion of the igniter is the same as in the Lefaucheux cartridge, see Fig. 3. *a* the brass

Fig. 2.

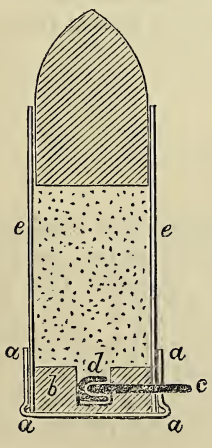
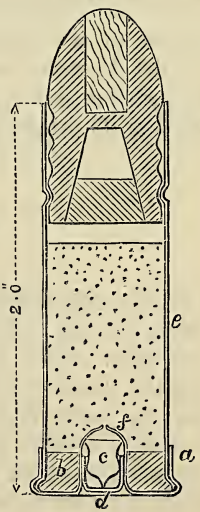


Fig. 3.



capsule, *b* papier-maché disc, *f* a cup with small aperture at the bottom and flanged at the mouth to prevent its being pushed bodily into the cartridge, *c* an anvil or small piece of metal with flat sides, *d* a common percussion cap of small size fitting neatly into the brass cup *f*, *e* the case, which in the Boxer cartridge is made of brass foil, *f* the cap chamber.

It may be worth while here to compare the bullet of the Boxer cartridge with that for the muzzle-loading Enfield. The lubrication for both is pure beeswax. In the case of the M.L. bullet it is applied on the outside of a paper envelope which is rammed down the barrel with the bullet, and thus to a certain extent lubricates the barrel before the charge is fired. In the bullet for the Boxer cartridge there are four grooves or cannelures round the bullet, and the beeswax is applied immediately to the bullet, these grooves ensuring the proper transmission and spreading of the lubrication on the interior of the barrel when the rifle is fired. Both bullets have a cavity at the base with clay plug, but the amount of work done by this plug in expanding the bullet is very different. The diameter of the barrel is 0·577″, of the M.L. bullet 0·55″, and of the B.L. bullet 0·573″, or the M.L. bullet has to be expanded 0·022″ to fit the barrel, and the B.L. bullet only 0·004″.

The M.L. bullet has a solid elliptical head, the B.L. bullet has an elliptical head with a cylindrical cavity in the apex, which extends to within 0·1″ from the cavity at the base. This cavity is plugged up with wood. The object is to lighten the fore part of the bullet which is found to produce a great effect upon its accuracy of flight.

The weight of the new bullet for the Snider rifle is 525 grains; only 5 grains less than the M.L. bullet.

Fig. 4.

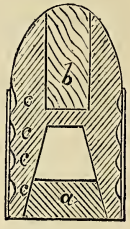


Fig. 4 is a section of this bullet.

a, clay plug in cavity at base,

b, wood plug completely filling the cylindrical cavity in the apex,

cc, cannelures to hold the lubrication,

The brass case of the Boxer cartridge extends sufficiently far over the bullet to cover and protect the lubrication, and the case is swaged into the cannelure nearest to the base of the bullet, which keeps the bullet in its proper place.

The Needle Gun.

Not only is this rifle different in its appearance and manipulation to all other B.L. rifles, but the cartridge is peculiar to it and not applicable to any other form of rifle. The bullet is shaped somewhat like an egg, the rear end being the smallest, and is somewhat flattened. It is rather less in diameter than the bore, and during its passage through the barrel does not touch it at all, the twist being communicated to it by means of a papier-maché wad or sabôt in which the bullet is bedded, the wad fitting the barrel closely. At the back of the sabôt is a circular patch of detonating compo-

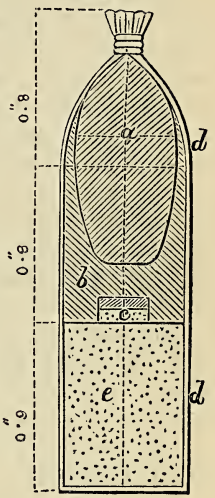
sition, the ingredients of which are erroneously supposed by many to be known only to the Prussian government.

The cartridge is of paper, enveloping powder, sabôt, and bullet, and is choked over the point of the bullet by means of fine twine or thread.

The firing apparatus or lock, if it can be so called, of the rifle is extremely simple, consisting only of a needle, spiral spring, and trigger. The needle is in continuation of the axis of the barrel at the breech end, and when the gun is cocked, as it must be when the breech is open, it does not appear at all. When fired the needle is pushed forward by the spiral spring through a small hole in the breech and advances right through the cartridge to the fulminate at the back of the sabôt to which the bullet is attached. The charge is thus lighted in front, preventing any of the grains of powder being driven out at the muzzle unexploded. The sabôt with bullet is blown out of the gun, the paper of the cartridge is destroyed, and, on opening the breech, it only requires re-loading.

Fig. 5 is a sketch of a section of a cartridge for the Prussian needle gun.

Fig. 5.



a, the bullet, *b*, papier-maché sabôt with fulminate at *c*, *d*, the paper envelope, and *e* the powder.

Escape of gas at the breech of the needle gun is prevented by a close mechanical fit of the plunger against the rear face of the barrel. The faces of both are coned, that of the plunger being concave and countersunk, and that of the barrel convex. By this arrangement any small escape which, with this description of gun is sure to take place unless it is new, is thrown forward away from the man who fires, but the escape of gas from the rifle of a rear rank man is apt to be troublesome to the front rank.*

The four cartridges already described are the only ones which have come largely into use, viz:—The copper rim fire cartridge, the pin cartridge, the central fire cartridge, and the cartridge for needle gun.

Of these the copper rim fire cartridge is by far the most simple and most easy to make waterproof. Its parts are when loaded with a solid bullet only five in number, viz:—

1. The copper case.
2. ,, powder.
3. ,, bullet.
4. ,, lubrication.
5. ,, fulminate.

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* A full description of this rifle will be found in the "Report of a professional tour of Officers of Royal Artillery, 1865," pp. 82–90, from which Fig. 5 has been taken.

The "Boxer cartridge" has as many as fourteen:—

1. The case of brass foil.
2. Thin paper cover.
3. Powder.
4. Cotton wool.
5. Bullet.
6. Clay plug.
7. Wood plug in apex.
8. Lubrication.
9. Papier-maché disc.
10. The brass capsule.
11. ,, brass cup or socket.
12. ,, anvil.
13. Copper cap.
14. Fulminate.

There is no doubt that these cartridges are waterpoof and serviceable, and that the bullet affords far greater precision with a 0·577″ bore than any other, and, moreover, that the precision up to 500 yards is nearly equal to that of a small bore rifle. But it would appear that a calibre of 0·577″ is too large to fire a bullet of only 530 grains which requires to be thus hollowed and lengthened to produce satisfactory results.

A calibre so small as 0·45″ with bullet and powder in the same quantities as at present used is open to several objections: (1) It is very liable to foul owing to the rapid rifling twist which becomes necessary. (2) The cartridge unless of special construction is very long, giving trouble in loading and withdrawing; and besides, more of the powder is blown out at the muzzle unconsumed than with a shorter cartridge.

In laying down the conditions which a new military rifle and its ammunition shall fulfil, the first point to be decided is the weight of the bullet, which should be as small as possible, with a due regard to efficiency in order that a soldier may carry as many rounds as possible.

The use of a rapid firing breech-loader renders this consideration all the more important.

The weight of the Enfield bullet is 530 grains, that of Westley Richards' B.L. small bore musket, of which there are 8000 in the service, is 480 grains, and it is hardened with antimony. The weight 530 grains is considered necessary to break the bone of a horse's leg at moderate ranges, but as the hardened 480 grain bullet has much greater penetration through elm planks the diminution of weight has been allowed. The bullet for the Prussian needle gun weighs 487 grains, a reduced bullet of only 349 grains was under consideration in that country in 1865, but has not been adopted.

It will be safe to conclude that an efficient and serviceable bullet should weigh about 500 grains, which will require a charge of about 75 grains. Next as to calibre. It having been shewn that 0·577″ is too large for a 525 or 530 grain bullet, and as 0·45″ has been found very liable to foul, some intermediate gauge is likely to be preferable to either, and simplicity in quantity leads us to a calibre of 0·50.″

The present total length of musket and bayonet being considered indispensable it will not be possible to reduce the weight of a new rifle below that of the Enfield rifle, viz. about 9 lbs. without bayonet.

It might be supposed that reducing the calibre from 0·577″ to 0·50″ would allow of a reduction in the weight of the barrel, but the present barrel of the Enfield rifle is well known to be too weak, especially near the muzzle; and if the calibre alone were reduced, leaving the thickness of the barrel the same as at present, it would make it still weaker. In order to retain equal strength, reduction in calibre must be accompanied by increased thickness of metal.

Grooves and Rifling.

The form and number of grooves is a matter of minor importance if the twist of rifling is sufficient. Of all service large bore arms the Lancaster oval bore carbine with which the Royal Engineers are armed shoots the best, but it has no very marked superiority in accuracy above the naval pattern rifle which is rifled with five grooves, the width of the lands being a little more than half that of the grooves. The bullet leaves the Lancaster carbine twisting at the rate of 1 turn in 64 inches; the naval rifle at 1 turn in 48 inches; and the long Enfield, '53 pattern, 1 turn in 72 inches. This latter twist is insufficient, the accuracy at long ranges being considerably inferior to that of the two shorter arms.

The best twist for a 500 grain bullet in a calibre of 0·50″ requires to be determined by experiment. The service small bore rifles with a calibre of 0·451″ have a rifle twist of 1 turn in 20 inches, which is probably more than is necessary, and it must be borne in mind that any superfluous rifling tends to heat and to foul the barrel.

It is probable that a twist of 1 in 35 inches or perhaps even 1 in 40 inches might be found sufficient for the above-mentioned calibre and charge.

Length of Barrel.

The length of barrel of an infantry rifle depends principally upon the total length of musket and bayonet which is considered necessary. All European nations adopt about the same length, viz. 6 feet; it then remains to be decided how much of this length shall consist of stock and barrel, and how much of bayonet. This has been settled more by practical considerations as to the most convenient length of bayonet, and the consequence is that the present length of barrel of the Enfield rifle (39 inches) is considerably greater than is required for accurate shooting.

The naval rifle and Lancaster carbines with barrels about 6 inches less than that of the long Enfield shoot very much better, owing doubtless to their steeper rifle twist.

With proper rifling the longer barrel could be made to shoot as well, but the length is not necessary to produce the accuracy.

The conditions enumerated are, to recapitulate:—

Bullet to weigh 500 grains.
Powder charge, 75 grains.
Weight of rifle without bayonet, 9 lbs.
Calibre, 0·5 inch.
Length of barrel, as at present, 39 inches.
Twist, 1 in 35 inches, or 1 in 40 inches.

There remain for consideration the lock and breech mechanism, and the description of cartridge.

The present Enfield lock is serviceable and durable, but when it is borne in mind that this description of lock was first introduced with the old flint and steel guns, and that the copper cap was invented partly with a view to its applicability to this lock; there seems no reason for slavishly adhering to it when the other parts about the breech of a gun have been so thoroughly revolutionized.

The spiral spring of the needle gun would be equally applicable to many other systems using either rim fire or central fire cartridges, and it would be very much cheaper to manufacture and to fit to the stock.

Systems of breech mechanism are so numerous that it is impossible to fix upon one which is decidedly superior to all others; indeed, it would be unreasonable to expect a faultless construction, when the number of conditions to be fulfilled is considered. Close fitting sliding surfaces are objectionable as being easily put out of order by a small quantity of dirt or rust. The base of the cartridge must be strongly supported so that there is no possibility of the breech being blown open. Escape of gas should be entirely prevented.

The motions necessary to open and close the breech and withdraw the cartridge case should be few and simple, and the cartridge should be effectually extracted so as to require no after motion to pick it out by hand.

If a rim fire or central fire cartridge is employed, a method of closing the breech is to be preferred, which during the last part of the closing motion presses home the cartridge if not pushed well home by hand.

As regards the cartridge none is so simple as the copper case with rim fire, and although no cartridge of this description has yet been made suitable for use with a charge of 75 grains of powder and 500 grain bullet, there is no reason to say that such a cartridge is an impossibility, and the simple metallic case does not necessitate the rim fire principle, but could be made available for central fire.

As before stated, the central fire principle in most general use is that of Potet, but seeing that this necessitates a hole in the base of the cartridge which has to be luted with beeswax to render it waterproof, it would appear preferable to try some plan in which the case does not require to be pierced.

When the bore of the gun is so small as 0·50″ the cartridge necessarily becomes rather too long, and to obviate this a plan has been tried in Germany and America of using a powder chamber of larger diameter than the bore of the gun, and of making the cartridge to fit it, this has the effect of disposing the powder in a better form for rapid combustion, and at the same time makes

it handier, better adapted to withstand rough usage, and easier to load and withdraw.

Fig. 6 is a full size sketch of a copper rim fire cartridge for Spencer's repeating rifle with enlarged powder chamber. Fig. 7 is a full sized sketch

Fig. 6.

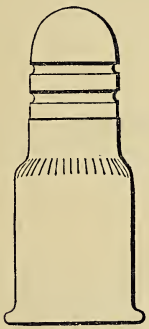
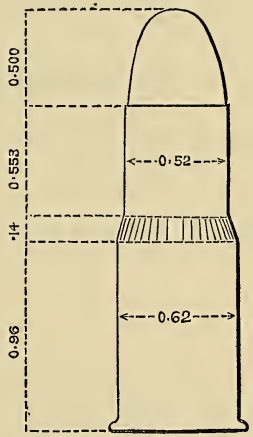


Fig. 7.



of a cartridge of similar construction suitable for a calibre of 0·5 inch and carrying 75 grains of powder and 500 grain bullet. It would weigh altogether about 700 grains or $\frac{1}{10}$th of a lb. The value of the copper in 100 of them would be less than 2*s*.

PLAN OF MUZZLE-PIVOTING GUNS.

BY LIEUT.-COLONEL SHAW, R.A.

From the Journal of the Royal United Service Institution, Vol. IX.

Having been invited by the Lecture Committee of this Institution to read to you this evening a paper on my system of muzzle-pivoting, I confess I was at first disposed to decline, as I knew the subject to be very dry, and easily exhausted, and I doubted my ability to make it commonly interesting; however, on reflecting that I had introduced this particular system into the Service, I thought it would be churlish of me not to endeavour to impart any information I might have on the subject to my professional brethren; to that end I wrote this paper.

Though this subject is one of great military importance, as far as attack and defence are concerned, it can hardly be deemed one of much general interest, consequently it is a difficult topic to enlarge upon; in fact, when I have told you the object of this system is to enable us to reduce the size of the ports and embrasures in armour-plated ships and forts to a minimum, without thereby affecting the efficiency of the range of their guns, I have told you nearly all that is to be said in its favour, provided it can be carried out in practice, and of this latter point I hope to convince you this evening before we separate.

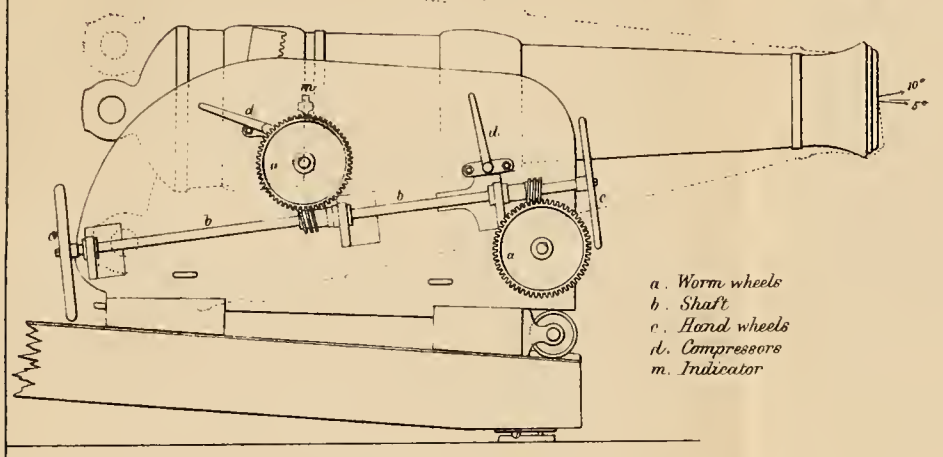
As far as I have been able to learn, Mr Robert Mallet, C.E., has the merit of having been the first to bring this subject to the notice of the Inspector-General of Fortifications, who acknowledged its importance in a military point of view, and referred Mr Mallet to the Ordnance Select Committee, but for some cause or other they did not consider that his plans could be carried out in practice, and so the matter was suffered to drop for the time.

I was first induced to take this subject up at the instigation of a gallant and talented officer of the Royal Engineers, who, in a conversation I had with him on the subject of armour-plating for forts, convinced me that to ensure strength and security, it is absolutely necessary to reduce the size of our embrasures to a minimum, and that can only be accomplished by a

Lieut. Col. Shaw's Muzzle Pivoting Carriage.

Scale ⅜ Inch to a Foot.

Fig. 6.



a. Worm wheels
b. Shaft
c. Hand wheels
d. Compressors
m. Indicator

Fig. 10.

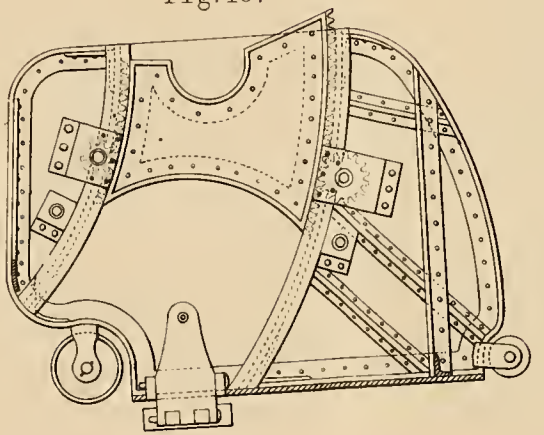


Fig. 12.

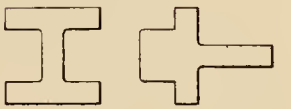
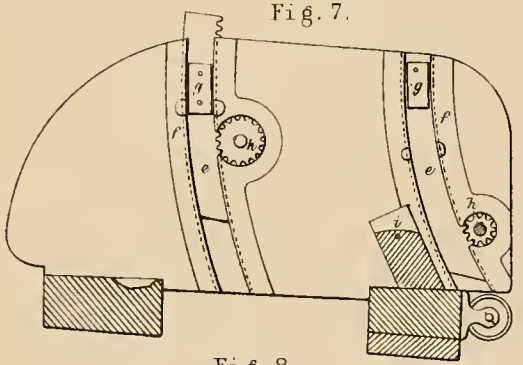
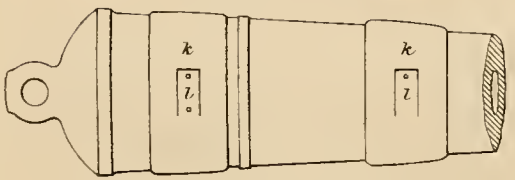


Fig. 7.



e. Arcs
f. Gun metal sockets
g. Supports for gun
h. Pinions
i. Transom

Fig. 8



k. Coils
l. Slots in do: for supporting the gun

Fig. 11.

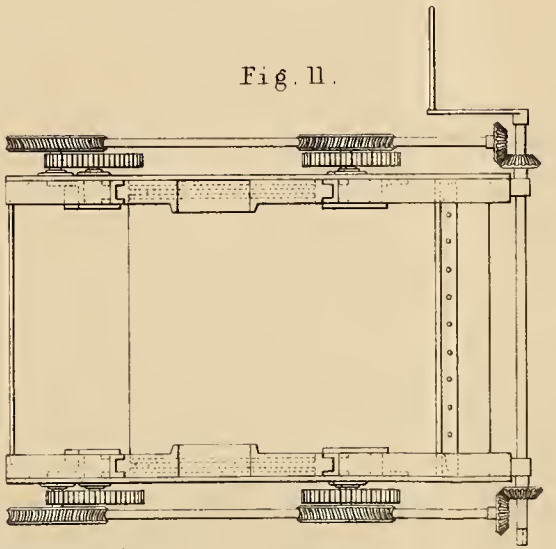


Fig. 13.

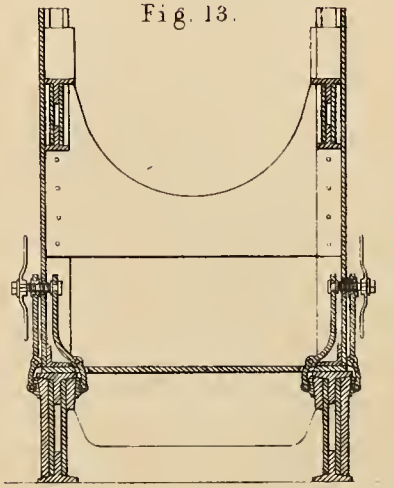


Fig. 1.

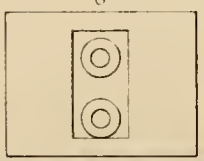


Fig. 2.

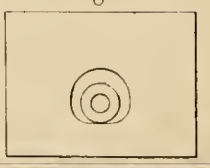


Fig. 3.
Bellerophon Port

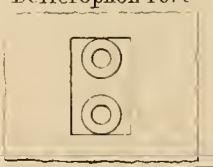


Fig. 4

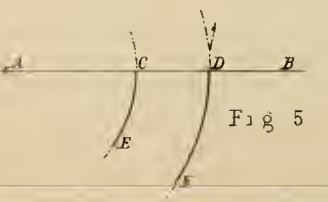


Fig 5

Scale ⅛ Inch to a Foot

Lithographed at the Royal Artillery Institution

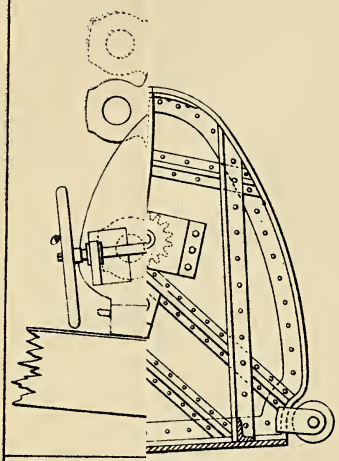


Fig. 12.

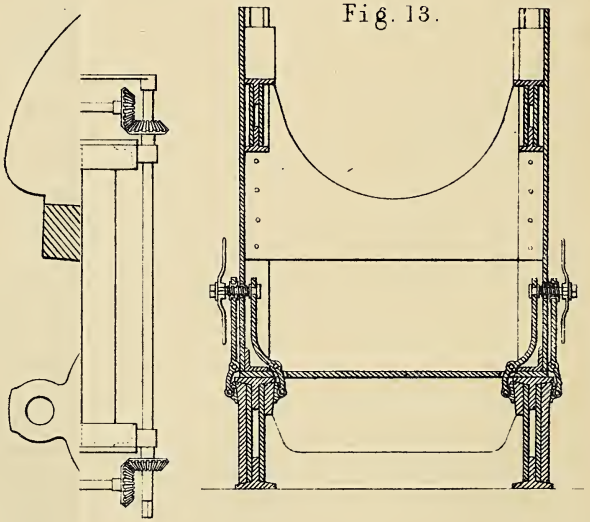


Fig. 13.

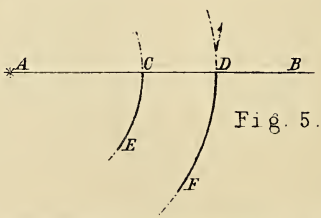


Fig. 5.

Lithographed at the Royal Artillery Institution

system of muzzle-pivoting; as it is quite clear that the height of the embrasure cannot be materially reduced, so long as the trunnion remains the centre of oscillation for elevation or depression; in fact, on the present system of elevation, the height of the embrasure depends on the length of the gun from the trunnions to the muzzle, representing the radius of the arc described by the muzzle when elevated or depressed.

An embrasure for a 12-ton gun elevated on the old principle, would have to be 4 ft. 6 in. high by 2 ft. 4 in. wide, so as to allow for a reasonable amount of elevation and depression; and supposing the shield for protecting the casemate to be 6 ft. by 8 ft., the embrasure old pattern would nearly cut it in half, and would only leave a strip of 9 in. of plating above and below which would detract enormously from the strength of the shield (*vide* Diagram, Plate I. Fig. 1), besides the embrasure would offer 11¼ feet open area for the admission of shot, shell, and rifle bullets, whereby the gunners might be picked off, and the gun and carriage disabled; and as modern guns and carriages are very expensive articles, it behoves us to protect them by every means in our power. For a 12-ton gun, elevated on my principle I should not require an embrasure to be more than on opening 2 ft. 4 in. in height, and the same in width (*vide* Diagram, Fig. 2), thereby affording complete protection to the gunners, gun, and carriage, and adding immensely to the strength of the shield.

In cupola ships on Captain Cowper Coles' plan, the want of a system of muzzle-pivoting is felt still more than in land fortifications, as in them, from their limited height above the deck, it is impossible, having due regard to the strength of the cupola, to have a port more than 2 ft. 9 in. in height; and to enable the gun, mounted on the ordinary carriage, to fire through this port, at different angles of elevation and depression, the platform on which the carriage is mounted has to be raised and lowered bodily by a very expensive arrangement of screws and wedges; the operation also is very tedious, whereas by adopting my principle the whole of this costly apparatus can be dispensed with, and the port can be considerably reduced. I am now making a 12-ton muzzle-pivoting wrought-iron carriage for the turret ship "Prince Albert," the size of the port will be 2 ft. 1 in., and the platform will be a fixture. In my opinion, this system is peculiarly adapted to this admirable class of ships; the turret itself being sighted, the man who lays the gun does not require to look through the port to get his object on, consequently it may be reduced to the exact size of the muzzle of the gun, thereby adding materially to the strength of the turret, and affording complete shelter to the gun's crew.

You will naturally ask, then why not make the ports in the "Prince Albert" the exact size of the muzzle of the gun? The reason is this, the turret is only 16 ft. 6 in. in interior diameter, and the gun itself is 11 ft. long, so that in order to allow room for recoil, I have to pivot the gun 1 ft. in from the muzzle, thereby slightly increasing the size of the port.

It is doubtful whether this system can be applied at present with advantage to broadside ports in iron-clad ships, as owing to the centre of motion being at the muzzle, the breech has to go through a much larger arc than when the motion is given from the trunnions; for instance, in a ship of the "Bellerophon" class, a 300-pr. mounted upon my principle would, when

at extreme depression, touch the beams; it would, no doubt, add greatly to the strength of the ship's side if the ports could be reduced to half their present size, at the same time the port-sills would be higher out of the water, and the crew would be better sheltered, but to obtain these advantages we must have a greater height between the decks.

The principal objections that have been urged against this principle of elevating, are, first, the slowness of the operation; and, secondly, so reducing the size of the port that the captain of the gun has not sufficient field of view to distinguish clearly the object at which he is aiming.

To the first of these objections, I attach little or no importance, as in actual warfare, sudden and rapid changes of elevation can never be required, and even if a sudden emergency did arise, it could be easily met, as in carriages constructed for muzzle-pivoting, the operations of elevating and loading can go on simultaneously, as I will explain hereafter.

The second objection I freely admit; it being quite certain that better practice is to be made from guns mounted *en barbette*, than from guns in casemates, firing through embrasures only a few inches larger than their muzzles; but if we expect perfect protection for our gunners, guns, and carriages, we cannot expect an unlimited field of view; however, as I propose leaving a space of 6 in. over the gun, which will be constant, I think the field of view will be quite as good if not better than it is at present in our iron-clad ships, where, when firing with extreme elevation, it is absolutely nil (*vide* Diagram, Fig. 3).

For all these reasons I came to the conclusion that our system of artillery would not be complete until muzzle-pivoting should be added to it. I consequently set earnestly to work to devise some practical method of pivoting guns at the muzzle, and in November, 1863, I laid before the Ordnance Select Committee a scheme for working a 68-pr. 95 cwt. gun on this principle on an ordinary casemate platform to give 10° elevation and 5° depression.

The Ordnance Select Committee approved of my proposal, and I was given a 68-pr. gun and ordered to make a carriage for it.

I will endeavour now to explain my system of muzzle-pivoting; first, the principle upon which I obtain the motion; and, secondly, the application of that principle to practice. Before going further into this question, I must explain that any material support or pivot to the muzzle of the gun would be quite inadmissible; as in the first place, it would be putting the working pivot of the gun in its most vulnerable point, thereby rendering it liable to injury at any moment; and, secondly, it would interfere with the working of the gun, as it would prevent its being run out in the embrasure or port. The pivot must be, so to say, imaginary, that is, the muzzle of the gun must be kept stationary, whilst the gun itself is being elevated or depressed, without any material support whatever.

From the centre A (*vide* Diagram, Fig. 5) describe two concentric circles, and from A draw the straight line AB, cutting the circumferences of these circles at C and D, from the same centre describe the arcs DF and CE; we will suppose these arcs to be attached to the line AB at C and D. Now if the line AB be moved about A as a fixed point, the arcs DF, CE will always move in the direction of the circumferences of concentric circles due to their

common centre *A*, and conversely if the arcs be moved in the direction of the circumferences of the two concentric circles, the point *A* will remain fixed. I will endeavour to illustrate this by means of a cardboard template I have had prepared of a 68-pr. gun. The axis of the piece coincides with the line *AB*, the point *A* being in the plane of the muzzle, and the lines on the arcs attached to the gun coinciding with the circumferences of the concentric circles. Now, if I put a pivot in the point *A* and move the gun through several degrees of elevation and depression, you will observe that the arcs attached to the gun invariably move in the direction of the circumferences of the concentric circles. It therefore struck me, that if I forced these arcs to move in the direction of the circumferences of circles due to their common centre by means of the concentric guide-pieces here shown, I should be able to dispense with the pivot at *A*, and the point *A* would remain fixed, and so the gun is pivoted at the muzzle. That, gentlemen, is the theory of my principle of muzzle-pivoting. Now to apply it to practice.

The woodwork of the carriage is put together in the usual way (see Fig. 6). The brackets are of 7 ft. teak, 3 ft. 6 in. high, 7 ft. 2 in. long, with a distance between them of 2 ft. 7 in. The transom is teak and the blocks sabicu. On reference to the diagram of the inside of the bracket (see Fig. 7), it will be seen that the concentric circles are represented by gun-metal sockets and the arcs are wrought-iron, 6 in. wide and 2 in. thick, toothed in front and made accurately to fit the sockets; of course the centre from which these arcs and sockets are described is at the muzzle of the gun. The sockets are cast with a pinion box and bearing for a shaft to go through to the outside of the bracket.

As the front set of arcs have a smaller radius than the hind set, they would have to move through a shorter space than the latter when the gun is raised or lowered. This proportion is regulated by the diameter and number of teeth in pinions which work the arcs. In this case the proportion is as 5 to 8; consequently the front set of pinions have a diameter of 5 in. and 10 teeth, and the hind set have a diameter of 8 in. and 16 teeth. The front set of pinions are keyed on a shaft, which goes through both brackets in front of the transom. On the outer ends of this shaft are worm-wheels 16 in. in diameter; the hind set of pinions are not connected by a shaft, but are each attached to a worm-wheel outside the bracket by a short shaft that works in the gun-metal bearing before alluded to.

The worm-wheels are worked by a shaft passing under the hind wheels and over the fore. This shaft has a right-handed screw worm for the hind wheel, and a corresponding left-hand screw worm for the front wheel. These shafts are turned by a cast-iron hand wheel at each end two feet in diameter.

The whole of this machinery is geared together by the shaft that connects the two front pinions. A compressor is fitted to each arc, which, when set up, takes the strain off the pinions. The degrees of elevation are marked on one of the worm-wheels, and the degrees of depression on one of the hind arcs.

With a power of 30 lbs. applied to each hand wheel, a weight of about 22,400 lbs. can be raised; of course we must deduct the friction, which in

this case would be considerable; and in practice the power is not found to be in excess, as nearly six tons dead weight have to be raised whenever the muzzle of the gun is depressed.

The gun is attached to the arcs in the following manner: on the inside of the arcs, and 4 in. above and below the axis of the gun, solid pieces of wrought-iron are forged on 8 in. high, 4 wide, and projecting inside the bracket 1·5 in. The gun is prepared to receive these supports by having its trunnions cut off (this is the worst feature in the system, as the gun is thereby rendered worthless for any other carriage), and having wrought-iron coils shrunk on at convenient distances in front and rear of the centre of gravity, and slots cut in the sides of these coils to correspond with the supports on the arcs, these slots being cut at distances from the muzzle of the gun corresponding to the radii of the arcs. These slots are cut through from the lower part of the coil to 4 in. above the plane of the axis of the gun, where 1·5 in. of metal is left to support the gun on the projecting pieces on the arcs.

The gun, when required to be mounted, is slung in the usual way (care being taken to keep it horizontal), and is lowered on the supports on the arcs which have previously been laid at point blank.

As in carriages constructed on this principle, the muzzle of the gun is always the same height from the deck or ground, it can be loaded at any degree of elevation or depression; and as the degrees of elevation are marked on the worm-wheel, the operations of loading and elevating can go on simultaneously, by which means much time is saved. Another advantage of this system is that when once the elevation is accurately ascertained any number of shots may be fired without re-adjustment, which is not the case with guns elevated on the principles which now obtain in the service. This is also the only carriage on which the degrees of depression are noted. Owing to this carriage being altogether of a new construction, and in the absence of special machinery, much of the work had to be done by hand, special tools had to be made and new patterns prepared, so that it was not finished until early in the spring of 1864, when the gun was mounted, and, without further fitting or alteration, was easily worked by four men. It pivoted exactly at the muzzle.

The gun and carriage were first inspected by the Ordnance Select Committee in the Royal Arsenal, when the gun was worked several times from extreme elevation to extreme depression; the time occupied in the operation was as nearly as possible three minutes and a half. The Committee, on a subsequent occasion, inspected the gun at the proof butt, when it was fired 10 rounds with service charges, of 16 lbs. of powder, and solid 68-pr. shot; the carriage was not the least shaken, and the gun worked quite as easily after as before the firing.

The gun and carriage were then ordered to be sent to Shoeburyness, to be fired 100 rounds, viz. 50 at 10° elevation, and 50 at extreme depression, and to be worked through an arc of 4° after each 10 rounds. I think perhaps the most impartial way of giving an account of the trials of this carriage at Shoeburyness will be to quote from the official Report furnished to the Ordnance Select Committee.

"The recoils varied from 3 ft. 9 in. with a wet platform, to 2 ft. 2 in. with

a dry one." Up to the 30th round, the gun worked easily through an arc of 4°; at the 40th round, the elevating arrangement worked slightly stiff. At the 51st round, the front hand wheel, on the right-hand side, broke off—all the others were cracked; at the 54th round, the left front wheel broke, the gun continued to work easily through an arc of 4° to the 70th round, when worked a little stiffly; at the 95th round, the gun ran down through an arc of 3°. The detachment can work the wheels while the gun is being loaded. Two wheels work almost "as easily as four. The process of depressing is somewhat tedious. At high angles of elevation the cheeks of the carriage interfere with the lanyard."

The Committee referred this report to me, and enquired how I proposed to remedy the defects therein set forth. I informed them in reply, that I was present at the trial, and that I observed two radical defects in the application of the power.—1st. The hand-wheels were too small, and should not have been of cast-iron; I propose to supply their place with wrought-iron winch handles. 2nd. The driving shafts are not directly connected, so that one can be worked slightly faster than the other, and so cause occasional stiffness. I propose to remedy this defect by connecting the present shafts by a cross shaft, and bevel wheel as here shown. The Committee assented to my proposals, and the carriage was altered accordingly, and again sent to Shoeburyness to be fired 100 rounds, under the same condition as before. For an account of this trial, I will again quote from the official Report:—

"Recoil with 10° elevation 2 ft. 6 in.

"Ditto 5° depression 4 ft. 3 in.

"The gun throughout the experiment was worked easily through an arc of 4° after every 10 rounds.

"The gun detachment consisted of one non-commissioned officer and eight gunners.

"The carriage, as altered, since last trial is greatly improved; fewer men can work it, and with greater ease. No difficulty of any kind was experienced, and no signs of weakness appeared anywhere. The compressors for jamming the toothed arcs acted perfectly.

"To alter the angle from 10° elevation to 5° depression, occupied the gun detachment 1½ minutes."

After this severe trial the Ordnance Select Committee had the gun and carriage returned to Woolwich Arsenal, where it now is, and in quite as good condition as when first sent to Shoeburyness; and I shall have great pleasure in showing the carriage to any Officer of either service who may wish to see it. This success of my first attempt at making a muzzle-pivoting carriage, emboldened me to lay before the Ordnance Select Committee a plan for mounting a 12-ton gun (without taking off the trunnions, or mutilating the gun in any way) on a wrought-iron muzzle-pivoting carriage, suitable for working in a cupola. The Committee approved of my design, and recommended the construction of two such carriages, for trial on board such of H.M. ships as the Lords Commissioners of the Admiralty might appoint. After some correspondence the Admiralty consented to a trial of one on board H.M. turret ship "Prince Albert," now fitting at Woolwich

Dockyard. The details of construction of this wrought-iron carriage are very different from those of the wooden 68-pr. I have just described, but the principle of muzzle-pivoting remains the same. With the aid of some diagrams I have had prepared, I will endeavour to describe this carriage to you. Here we have, Plate II. Fig. 9, a side view of the carriage on its slide, with the gun mounted, and shown at elevation and depression, in the port of the cupola; as I before stated, in this case, owing to the interior diameter of the cupola being only 16 ft. 6 in., and the gun being 11 ft. long, in order to leave reasonable room for recoil, I have been obliged to pivot the gun 1 ft. in from the muzzle, which causes the port to be slightly larger than if I had pivoted it exactly at the muzzle. This carriage is constructed in frames of 5 in. angle iron, $\frac{7}{8}$ in. thick; the bottom is of boiler plate 1 in. thick; the sides are of $\frac{7}{8}$ in. boiler plate, 4 ft. 11 in. high, 7 ft. long; the transoms are also of $\frac{7}{8}$ in. plate; the different stays are of $\frac{7}{8}$ in. T iron.

Now to obtain muzzle, or rather 1 ft. from muzzle-pivoting, I describe my two concentric circles with radii of 5 ft. 2 in., and 8 ft. $\frac{5}{8}$ in. (see Figs. 10 and 11, Plate I.), and between them I place a girder built of strong T iron, and boiler plate, capable of supporting many tons. In front and rear this girder is bounded by arcs, described with the same radii as the concentric guide pieces. This being done with both brackets, these girders, which you see are provided with trunnion-holes, are tied together with a strong iron band, fitted to the shape of the gun, and so form a moveable cradle for the gun to rest in. The section of the arcs in front and rear of the girders is of this form ⊢, the projecting portion being toothed, and the section of the concentric guide pieces is ⊥ so that one section fits exactly into the other. That portion of the angle iron between the tops of the concentric guide pieces is cut away (the bracket being proportionately strengthened on the outside), and the cradle is lowered down between the guide pieces, till it rests on the pinions front and rear; these pinions are worked similarly to those in the wooden carriage, with the addition of a toothed wheel to increase the power. The sides are secured to the bottom by means of angle iron and rivets, and are tied together by two transoms, which are made as deep as possible, and hollowed out in the way of gun. As the guide pieces have to sustain the shock of the discharge of the gun, they are supported by strong stays of T iron; the whole of the pinion wheels and shafts work in metal bearings, to prevent being set fast, while means are provided for getting readily at all parts for the purpose of cleaning, oiling, and repair. This carriage works upon a slide (Fig. 13), which is, as long as the cupola will admit; it is constructed of T iron and boiler plate, the lower piece of T iron is bolted to the floor of the cupola; the slope of the side is 4°.

As a breeching rope would be much in the way, a breast chain is substituted for it, to limit the recoil, while a rack on each side of the slide and pauls upon the sides of the carriage, preclude the possibility of the gun running out from a sudden lurch, or any other cause.

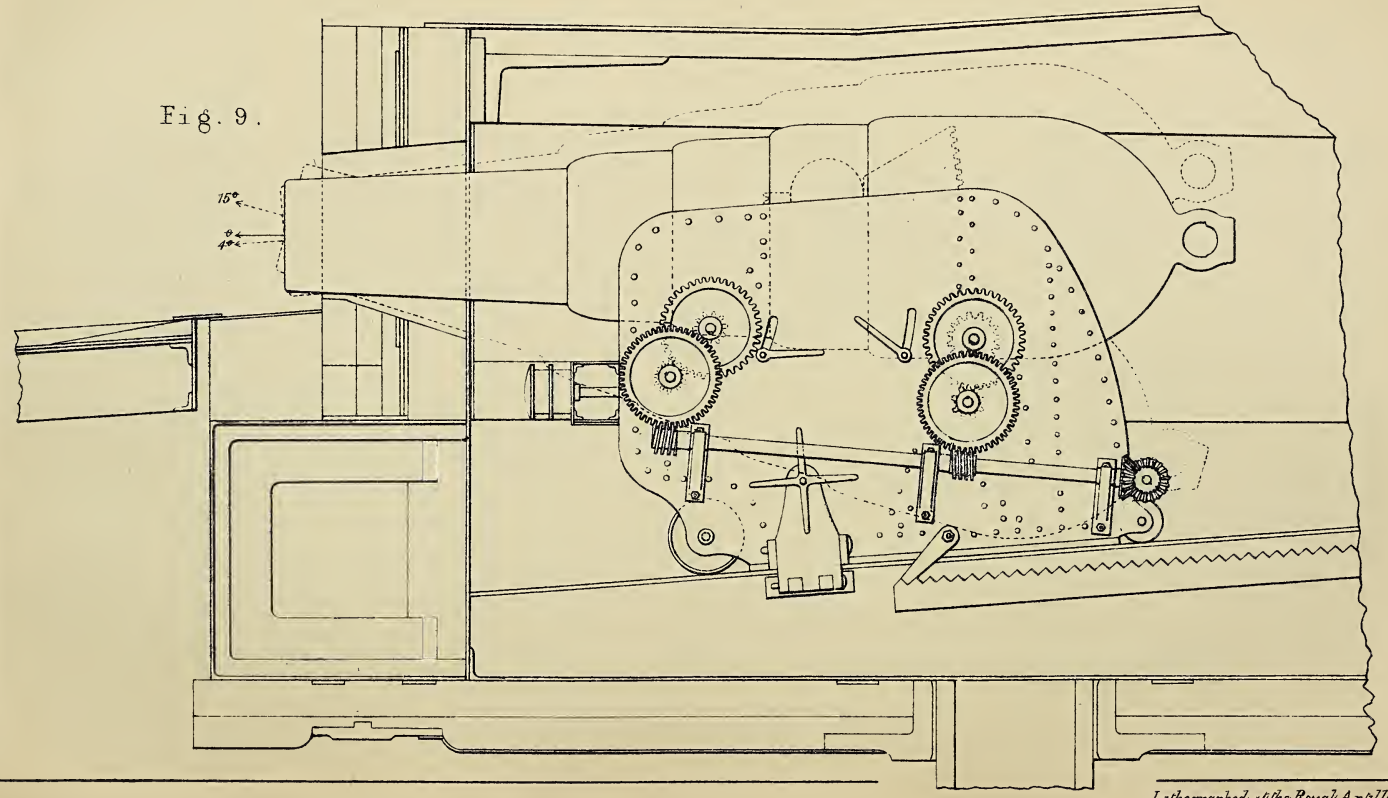
The carriage will be run in by an arrangement of tackle, devised by Capt. Coles, and already at work in the cupolas of the "Royal Sovereign."

Buffers constructed of india-rubber rings are placed on the front of the carriage, to lessen the concussion when the gun is run out.

Lieut. Col. Shaw's Muzzle Pivoting Carriage.

Scale 3/8 Inch to a Foot.

Fig. 9.



Lithographed at the Royal Artillery Institution

The compressors for this carriage (Fig. 13) serve a twofold purpose, namely, the usual one of controlling the recoil, and the other of tying the carriage securely down upon the slide; they consist of plates hinged to the bottom of the bracket, with a screw at their upper ends, working in a female thread against the face of the other, their lower ends are fitted with hanging plates, to grip the wooden fittings of the platform, which are slightly tapered towards the lower edge, so that the action of these compressors, when their upper ends are forced outwards, will be not only to grip the wood on the sides of the slide, but also to bring the bottom of the carriage and top of the slide into closest possible contact.

The arrangement for compressing the cradle to the main carriage was difficult to manage, as the only available space where the compressors could act on the cradle at all degrees of elevation and depression is occupied by the pinion and toothed wheels; the only way I could think of to get over this dilemma, was to make the compressors moveable. Their own weight keeps them in place when the gun is fired at elevation, and when fired at depression a stop on the bottom of each girder raises them to their proper position; they act on the cradle and carriage by jamming a small bevelled plate attached to the eccentric lever of the compressor against a similar bevelled plate fixed to the girder, and so tying the cradle to the side plates, by which means the teeth of the pinions and racks are relieved from the full force of the concussion arising from the discharge of the gun.

I have now brought you to the point where this system is at present. I consider it as yet quite in its infancy, and have no doubt great improvements will be made in it. I do not see why, with proper management, steam power, hydraulic pressure, or compressed air, might not be brought to bear their part in lifting very heavy guns mounted on this principle; but whatever progress may be made in the working of this system, I do not think the fundamental principle of pivoting the muzzle by working the gun on arcs moving in the direction of the circumferences of concentric circles due to their common centre at the muzzle, will be much improved upon. I hope you will not consider that I am wandering from my text, if in connection with this subject I venture to say a few words on the mounting of our very heavy guns. It is my opinion—and I know that opinion to be shared by numbers of our most experienced officers of artillery—that all guns of 12-tons and upwards, whether for land or sea service, should be mounted in revolving turrets or cupolas. It is surely a pity to confine the range of these powerful guns to the limited angle of training to be obtained in any port or embrasure; whereas a gun mounted in a turret is completely protected, and, at the same time, has an unlimited range and field of view. This is the only method of mounting a gun that combines these two conditions. Two guns mounted side by side in a turret would be quite equal to six mounted in any other way. It is also my opinion that no gun heavier than 12 tons ought to be mounted on board ship, either in turrets or at broadside. I do not say for a moment that a 22-ton gun could not be worked in a turret in tolerably smooth water, on the contrary, nothing would be easier, and if the gun could be a fixture, like the engine or boilers, there would be little danger; but, unfortunately, to be useful, a gun must be moveable, and the only way to secure it in rough weather is by chains and

ropes. Theoretically, chains will not break under certain known pressure; hooks will not draw; blocks will not carry away; but we all know in practice these things do happen. I have seen a chain break with a weight of five tons that ought not to have failed with 30. The very block of the tackle that mounted the 22-ton gun with perfect safety the other day at Woolwich, broke like a carrot when dismounting it, and let the gun go by run; luckily it fell on soft ground, and no harm was done. I do not think the captain of the "Prince Consort" would have felt very comfortable if he had had a couple of 600-prs. on board his ship during the gale he met with in the Irish Channel. And why run the risk? What more powerful gun can be wanted than the 12-ton 9·22"? It will throw a shell weighing nearly 300 lbs. containing fifteen pounds of powder with wonderful accuracy, as far as we can see. Within 1000 yds., with steel shell, it will sink the strongest iron-clad afloat. Far better have two 12-ton guns on board a ship than one 22-ton gun. Two guns form a battery, one does not.

I have now told you all I know on the subject of muzzle-pivoting, and it only remains for me to thank you for the kind attention with which you have listened to a dry and purely professional paper. My object has been to convey to you, in the plainest possible words, what I consider to be the advantages to be derived from a system of muzzle-pivoting, and to explain how that system was to be carried out in practice. If I have succeeded in so doing I am perfectly satisfied.

NOTE BY LIEUT.-COLONEL SHAW.

Woolwich,
5th January, 1867.

Since the above paper was printed the wrought-iron muzzle pivoting carriage for H.M. ship "Prince Albert" has been completed, and issued for service on board that ship. In the course of manufacture it was found desirable to alter some of the details of construction; for instance, it was not considered advisable to fit the compressors for controlling the recoil as originally designed, and the compressors, for tying the cradle to the main carriages, are dispensed with, so is the paul on the carriage, and the rack on the slides, and the running in and out gear is different from any other carriages mounted in turrets or elsewhere.

The compressor now fitted to this carriage was designed by Mr Smith, master fitter, Royal Carriage Department, and consists of a short length of 8" girder iron, just long enough to fit between the sides of the slide; it is placed on its side, and the two ends on the upper side are filled up with iron faced with copper, so as to fit the under side of the projecting piece of T iron that forms the top of the slide through each end, but clear of the slide, a socket is fitted and tapped with the female thread of a three-inch screw, which screw works through the bottom of the carriage;

they are fitted with worm wheel heads, and are operated upon by a shaft passing through the front of the carriage, fitted with the necessary worms and handwheels. The action of this compressor is to squeeze the T iron, which forms the top of the slide, between the bottom of the carriage and the girder, as in a vice, and as by this arrangement of screws and worm wheels, an enormous amount of pressure can be obtained, in fact, when the compressor is set up, the carriage may be said to form a part and portion of the slide, and be quite immovable in the roughest weather; and I know that the gun was fired when the ship was rolling 16° both ways, and was under perfect control, which was not the case with the other guns on board.

The running in and out gear for this carriage is fitted as follows:—A powerful winch is fixed in rear of the turret, and between the sides of the slide; in the fore part of the turret a pulley is fixed to the deck fitted with a set screw, an endless flat chain is passed round this pully and the barrel of the winch, it also passes through a slot in an iron bracket under the carriage, into which a strong iron plunger is fitted, so as to work up and down by means of a screw fitted with an elevating screw head; when the carriage is to be attached to the chain for running in or out a turn of the screw drives the plunger down between the links of the chain and fixes the carriage to it, and a turn the opposite way immediately releases it when required for firing.

This carriage and slide were completed in November, 1865, and a 9″ 12-ton gun was mounted and found to work perfectly. Four men, with the hand wheels, raised the gun through an arc of 10° in five minutes; and with winch handles, they raised it through an arc of 14·75° in four minutes; twelve men with long winch handles, raised it 14·75° in two minutes and twenty seconds, it can be run down in two minutes. Four men can easily alter the elevation one degree in twenty seconds.

On the 27th November, 1865, the gun was mounted on its carriage and slide in front of the Proof Butt, Royal Arsenal, for the purpose of firing ten rounds to test the strength of the carriage previous to shipping it on board the "Prince Albert" which was then lying in Woolwich Dockyard. There were present on the occasion Major-General Warde, Rear-Admiral Caffin, Commodore Dunlop, the members of the Ordnance Select Committee, and a number of officers of both services. The charge was 40 lbs. of powder and a shell of 260 lbs. The result of the firing was as follows:—

1st round, 2 men at the compressors, recoil 7 ft., breeching chain broke, owing to a faulty attachment to the carriage.
2nd round, 4 men at compressors, recoil 6 feet.
3rd " 5 " " " 4·9 "
4th " 6 " " " 4·4 "

I suspended the firing here in order to have the defects of the breeching made good, which was done by attaching it to the carriage with a swivel to secure an equal strain on each part of the chain. The firing was resumed on the 8th of December with the following results:—

5th round,	2 men at compressors,			recoil	4′	9″
6th	"	2	"	"	"	4	3½
7th	"	2	"	"	"	4	8½
8th	"	1	"	"	"	4	8½
9th	"	compressor slack.				5	2

taut breeching, india-rubber rings on breeching, both compressed, 2¼ inches.

10th round, 1 man at compressor, 4′ 8½″, everything about the carriage, slide, compressor and breeching perfectly sound and in good order.

Shortly after this trial the gun carriage and slide were shipped on board H.M. ship "Prince Albert," and mounted in the foremost turret and the whole were in perfect working order when the ship sailed for Devonport.

Although this carriage has been under trial by the Admiralty for nearly a year, I regret to say that I have not been able to obtain any official information as to its efficiency or otherwise, but I have heard from private sources that a good many rounds have been fired from it, some when the vessel was rolling 16° both ways, and the gun was under perfect control, it was also fired with battering charges (42 lbs. powder) at 14° elevation. The carriage is still on board the "Prince Albert," (she is attached to H.M. ship "Cambridge" for exercise), and in the absence of any report to the contrary, it is fair to assume that it is still in a serviceable condition.

BOXER AMMUNITION

FOR SNIDER CONVERTED RIFLE.

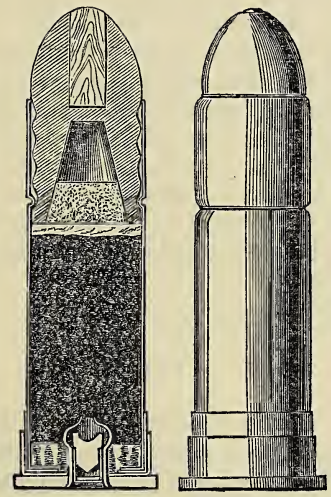
BY CAPTAIN C. O. BROWNE, R.A.

CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

THE following are the chief features which individualize it, and contribute to its effect.

Bullet.

The bullet is a modified form of the service Enfield (*vide* section below), length 1·12″.



It is of such diameter (·573″) as to drop through the bore, round the cylindrical part run four cannelures filled with pure beeswax, which is also spread over the bullet bringing it up to ·577″ diameter.

It has a cylindrical hollow in the head, depth ·52″, plugged up with sycamore wood.

It has a conical hollow in the base, depth ·503″, in which is inserted a plug of pressed clay baked and soaked in beeswax.

Weight of bullet including plug, 525 grains.

On this bullet mainly depends the accuracy of the piece, both with reference to each individual shot, and to keeping up the shooting for any great number of rounds in spite of fouling action.

Action of Bullet.

It may be noticed that the bullet in Westley Richards, or any breech loader of that class, is forced through a bore of smaller diameter than itself, here on the other hand it enters the grooves by expansion, squeezing the lubricant out between its own surface and that of the bore, thus the lubrication does not depend on a wad left by a previous round, but simply on the bullet itself which has no lubricating wad whatever; in fact, the action which ordinarily causes fouling, here cleans the barrel: this was exemplified by a rusty rifle fired experimentally, which after a certain number of rounds, shot as well as a clean piece.

The effect of hollowing out the bullet is to place its centre of gravity in such a position, and to give it such proportions as to enable the same ball to shoot well with both the service twists, viz. one in six feet six inches, and one in four feet.

A shorter bullet with a solid head answered well with the long barrel and slower twist, but not with the more rapid one.

Besides the length and external form being affected by the hollow, the spin of the bullet is steadier, because by the mass being distributed further from the axis the radius of gyration is lengthened.

On this principle a large flat top spins better than a tall one.

On this principle a rifled shell carries more truly than a shot.

The fact that more work is done on the barrel in spinning a projectile with an increased radius of gyration is of trifling importance in small arms.

The curve of the head is that which is found by practice to give the best effect, this tells chiefly towards the latter end of the bullet's flight where its axis deviates most from the tangent to the trajectory. If this bullet's point be cut conical or even slightly altered in form by shaving the shooting falls off, especially at long ranges.

Case.

The case holding in one the powder (charge 2½ drs. rifle F.G.) and bullet extends up as far as the shoulder of the latter, it consists of sheet brass rolled to ·003″ thickness and annealed, cut in a rectangular strip of such a length as to wind round the charge with two complete turns and a little overlap, it is choked into the rear cannelure of the bullet and covered with thin white paper attached by shellac and india-rubber cement. A layer of cotton wool is placed between the powder and base of the bullet which with the choking completely prevents escape of any grains of powder or the entrance of moisture. The case is fixed at the base in a brass cup (*vide* Fig.), being protected from the edge of the latter, which might otherwise cut it in firing, by a narrow strip of sheet brass termed the "base coil." The "base cup" contains the "cap chamber" in which is placed the detonator (*vide* Fig.) being supported by a brown paper pellet rammed in tightly round the cap chamber and holding the sheet brass firmly to the inside of the cup, besides pressing out and supporting the latter during discharge. On the end of the base cup is a "base disc," riveted on by means of the cap chamber, this disc fits the

shoulder in the breech of the barrel with a close joint, by it the empty case is extracted after discharge.

Up to the present time the "base disc" has been made of sheet brass, but Colonel Boxer proposes to use tinned iron instead for economy.

The advantage of attaching a solid disc in place of forcing the base cup into the beading common to metallic cartridges is very great, for the metal in forming a beading undergoes such distortion that the base is liable to be weak, and to give way on firing causing dangerous escape of gas at the breech.

The solid disc is also more simple to manufacture.

The detonator consists of a cap and an anvil, the former resembles a pistol cap, made of a disc of copper annealed after its formation to save it from splitting and to cause it to expand and bulge out to the exclusion of gas at the centre of the base of the cartridge. The anvil is stamped from sheet brass and inserted with its point towards the detonating composition in the cap.

Keeping Qualities.

The cartridge thus formed has the following keeping qualities :—

It may be submerged in water without suffering.

It will stand very rough usage without allowing any grains of powder to escape or without altering in form to an injurious extent.

Packing.

As to packing compared with the service Enfield,—

A quarter-barrel contains 700 rounds of Enfield '53 including caps, and weighs 74½ lbs., or 760 rounds of Boxer's ammunition, weight 86 lbs. 6 oz.

Action.

It combines a loose fit, giving easy entrance and extraction with prevention of escape of gas as follows. On the hammer striking the piston which ignites the cap on the anvil, the peculiar construction of the case enables the thin metal on the expansion of exploded gas to open or unwind till it presses against the sides of the chamber and receives sufficient support to prevent it from splitting and so allowing leakage or escape.

After discharge the case so far returns to its former size as to be loose enough for easy withdrawal when it is found unsplit and cylindrical in form even though it may have been very much dented and out of shape when inserted.

Price.

The price of the Enfield '53 ammunition is about £2. 3s. and of the Boxer £3. 3s. 3d. per thousand rounds.

The peculiar features of this ammunition may be summed up thus :—

(1) The rolled or winding case.

(2) The solid base disc.

(3) The low diameter of bullet, and system of lubricating without wad.

(4) Beeswax lubricant, and baked clay plug.

(5) Form and mass of hollowed bullet suited to both service twists.*

(6) Attachment of bullet to cartridge to resist rough usage and exposure to wet.

The Committee report that the Snider converted rifle with this ammunition compared with the service Enfield muzzle loader,—

Fires without aiming fifteen rounds in a minute in place of three.
Taking aim it fires nearly three times as fast.
It gives 30 per cent. more accuracy. It stands exposure to weather and rough usage better. It is easier to clean, and is less liable to miss fire.

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* It has been found that such very slight alterations in conditions in powder and rifle affect the shooting of this ammunition with the long Enfield rifle that it has been decided to adopt another pattern with a shorter bullet for that arm.

It is probable both patterns will be issued for service, each to be kept if possible to its own rifle, viz.:

Long bullet to short rifle,
Short bullet to long rifle.

Should the ammunition be issued indiscriminately, the shooting will probably be less accurate, but this may be done on an emergency.

ROUGH NOTES

ON THE

HISTORY OF FIELD ARTILLERY.

BY LIEUT. H. W. HIME, R.A.

Field Artillery, applying this term to a confused mass of military machines, seems to have first come into general use in Flanders, the ballistæ being gradually replaced by 1-prs. and 2-prs. which were carried by twos or fours in carts. In 1382, 5000 men of Ghent formed themselves into a dense mass surrounded by 200 small cannon, and succeeded in driving off 40,000 men of Bruges.

What the guns at this early period must have been may be imagined when one learns that a century later, during the invasion of Italy by Charles VIII. so unwieldy were the guns that the besieged had time to repair the damage done by one shot before the next could be fired.[1]

Perhaps the earliest mention of anything like a manœuvre of artillery on the field of battle may be found in the account of the battle of Aubin du Cormier, 1488, where the French guns were brought to bear on the flank of the English and Germans, and did some execution.

In the time of Henri II. of France,[2] artillery carriages were still in so bad a state, that when it was desired to advance the guns when in "action," the movement was performed by hooking the horses to the front of the cheeks of the carriage, in order to avoid limbering up or reversing.[3]

The guns were at this time as clumsy as the carriages, the bastard which threw a ball of 7 lbs. weighing 22 cwt. Indeed, it is impossible to avoid concluding that the destructive power of the artillery at this period was exceedingly small, and that its usefulness depended almost entirely on its

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[1] Favé. "Histoire et Tactique des Trois Armes," p. 23.

[2] The above statements are taken from an anonymous article on "Gun Carriages" in an old number of Colburn's "United Service Magazine."

[3] The prolonge is said to have been invented by Machiavelli, cir. 1500.

moral effect. Perhaps Spenser's account of the discharge of a cannon may give a colour to this statement.:—

> "As when that divelish yron engin, wrought
> In deepest hell, and framed by furies' skill,
> With windy nitre and quick sulphur fraught,
> And ramd with bollet rownd, ordained to kill,
> Conceiveth fyre: the heavens it doth fill
> With thundering noyse, and all the ayre doth choke
> That none can breathe, nor see, nor heare at will,
> Thro' smouldering cloud of duskish stinking smoke,
> That th' only breath him daunts, that hath escaped the stroke.[1]"

Shakespeare, a little later, makes frequent mention of artillery, speaking of "the fatal balls of murdering basilisks,"[2] and the "dangerous artillery" of Bourdeaux.[3]

During the Thirty Years' War, artillery was considerably improved on the continent by Gustavus Adolphus, and one of the earliest attempts at combining cavalry and field artillery was made by that monarch at Dirschen, and with success. At Lützen, 1632, he again made good use of his artillery. He was singular however in his knowledge of this arm. The loss of the battle of Leipsic, 1631, by Tilly may be almost entirely attributed to his utter ignorance of the use of artillery:

(1) He posted his guns behind his infantry, firing over their heads, so that he could not advance without masking the fire of his own guns;

(2) He did advance and thereby masked them;

(3) He permitted the enemy to change front in his presence without a struggle, Gustavus covering this manœuvre with his leather guns; the consequence of which was that Tilly's guns were captured and turned against himself.[4]

Artillery in England at this time was in a very backward state, for during the French wars the navy had been so improved that comparatively speaking England was safe from invasion, and consequently from the close of those wars in 1559 the army had been neglected in all its branches. At Edge Hill and Marston Moor the Roundheads had no guns, but the Cavaliers were so totally unacquainted with the use of theirs, that the presence of their artillery on the field afforded them but very little advantage. As late as the battle of Sedgemoor, 1685, "so defective were the appointments of an

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[1] "Faerie Queen." Book I. chap. vii. sect. 13.

[2] "Henry V." Act 5. Sc. 2.

[3] First part of "Henry VI." Act 4, Sc. 2. It may be doubted whether the word "Artillery" here means "Artillerie *à feu*," as this word when used in the Bible, which was translated after Henry VI. was written, refers to bows and arrows, and at that time included all *machines de guerre*. As however the translators of the Bible were directed to follow the old editions of the Bible, their language is much more antiquated than that of the time in which they wrote, and it is quite possible that Shakespeare used the word in the modern sense.

[4] See Schiller's "History of the Thirty Years' War."

English army, that there would have been much difficulty in dragging the great guns to the place where the battle was raging, had not the Bishop of Winchester offered his coach-horses and traces for the purpose."[1] Even when the guns had arrived, there was so great a want of gunners to work the guns that a serjeant of Dumbarton's Regiment, (the 1st Royals), named Weems, was forced to take on himself the management of several pieces, and for which he received a gratuity of £40, "for good service in the action at Sedgemoor, in firing the great guns against the rebels."[2]

Passing on to Marlborough's time we find a greater proportion of artillery allotted to an army than had previously been the case. At Blenheim the proportion of guns was 1·2 per 1000 men. After the first attacks in this battle, finding he could make no impression on the enemy, Marlborough ordered Colonel Blood of the British artillery to take a battery across the river by a bridge which had been formed, and this artillery manœuvre materially contributed to the success of the day.[3]

At Ramilies he had two guns per 1000 men, a large proportion considering the state of the ordnance then, and at Malplaquet 1·1 guns per 1000 men.

This latter battle affords perhaps the first instance of a fight in which when the crisis arrived, the deciding stroke was given by the artillery. Having succeeded in piercing the French centre, Marlborough "instantly gave the grand battery of 40 guns in the allied centre orders to advance. With the utmost rapidity the guns were limbered up, and moving on at a quick trot, they soon passed the retrenchments in the centre, and facing to the right and left (i.e. wheeling outwards by wings) opened a tremendous fire of canister and grape on the dense masses of French cavalry which stood in the rear of the infantry..... Villars' position ..... was no longer tenable. Pierced through the centre, with a formidable enemy's battery on either side thundering on the reserve squadrons, in the very heart of his lines, it had become hopeless to attempt to keep the field."[4]

This example alone proves that Marlborough was as great a general of artillery as he was a leader of cavalry; and that he made no better use of his guns in his other battles is easily accounted for when we read that at Oudenarde "few pieces of artillery were brought up on either side, the rapidity of the movements of both having outstripped the slow pace at which those ponderous implements of destruction were then conveyed."[5]

The importance of artillery but gradually forced itself upon the minds of the English, and it was not till 1727 that the Royal Regiment of Artillery was formed of the companies of the Regimental Artillery Train.

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[1] Macaulay's "History of England."

[2] "Notes on the early history of the Royal Artillery" in the "Proceedings" of the R.A. Institution, Vol. II. p. 128. By Capt. Yonge, R.A.

[3] Aide-Mémoire. Art. Ordnance.

[4] Alison. "Life of Marlborough," Vol. II. p. 58. Favé. "Histoire et Tactique des Trois Armes," p. 98. It seems odd to an English officer to find, in Capt. Favé's detailed account of this battle, the Duke of Marlborough's name only *once* mentioned as the commander of an English force attached to the German army. All the manœuvres are represented as having been ordered by, and all the success is attributed to, Prince Eugene.

[5] Alison's "Life of Marlborough," Vol. I. p. 396.

The great vices of the artillery of this period were the extreme weight and length of the larger pieces, and the enormous recoil and short ranges of the smaller ones: and de Vallière's system (1720), founded on the union of field and garrison artillery did not escape these faults.

Although the germ of mobility in field artillery is traceable to the Swedish artillery of the Thirty Years' War, yet the tactics of this arm, i.e. the art of manœuvring it in the face of the enemy, cannot be said to have had any existence till the close of the Seven Years' War: and even as late as the battle of Zorndorff the powers of artillery had been so little developed as to entirely justify Favé in his remark on this battle,—"à cette époque encore, malgré ses accroissements, l'artillerie était un auxiliare, et non une arme."[1]

In 1759 Frederick the Great formed a brigade of horse artillery of ten light 6-prs.[2] He was led to take this step by the want of mobility of his field artillery, and by a desire to possess a force of guns that could manœuvre with his cavalry,—a matter which had now become of paramount importance owing to certain improvements which he had introduced into the manœuvres of his cavalry.

On his accession to the throne he found the cavalry drilled to fire in line at the halt;[3] but recognizing the principle that motion is a necessary condition of the action of cavalry as cavalry,[4] he abolished this evolution, and to supply his cavalry with a powerful fire, without injuring the special action of this arm, he formed horse artillery,—the only step by which such a result was attainable.[5] Napoleon supports this theory fully when he says,—"La cavalerie ne rend pas de feux, et ne peut se battre qu' à l'arme blanche. C'est pour subvenir à ce besoin qu'on a créé l'artillerie à cheval."[6] In other words, Frederick having deprived cavalry of the fire which up to his time it had possessed in itself, felt bound to furnish it with a substitute, and horse artillery was consequently formed.

At the battle of Dettingen, 1743, it is probable that there were three companies of Royal Artillery,[7] but of their services little is known. The French lost the battle by the Duc de Grammont's advance which masked a large portion of the French artillery—a repetition of Tilly's mistake at Leipsic.

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[1] "Hist. et Tact. des Trois Armes," p. 140

[2] *Ibid.* p. 144. Giustiniani, "Essai sur la Tactique des Trois Armes," p. 221. Taubert, "On Field Artillery," p. 11.

[3] Jervis, "Manual of Field Operations," p. 50. Nolan, "Cavalry Tactics," p. 30.

[4] De Ternay, "Traitè de Tactique," Tom. I. p. 269. Jomini, Précis," Chap. 7, Art. 45. Giustiniani, "Essai," p. 183.

The conduct of Frederick's cavalry, afterwards so distinguished, was at the beginning of his wars quite as bad as might have been expected from a cavalry trained to depend on the carbine instead of the sabre. The following is an extract from an order which he was compelled to issue after his first battle, Molwitz, 1741, from which indeed he fled himself, and from having taken refuge in a mill was said to have "covered himself with glory and with flour."

Par. 13. "If the cavalry ordered for the attack shall be repulsed, as at Molwitz, the grenadiers shall fire on them, even to exterminating them entirely."—British Military Library, Vol. II.

[5] Monhaupt, "Tactique de l'Artillerie a cheval," p. 4.

[6] Montholon, Tom. III. p. 261.

[7] "England's Artilleryman," p. 11.

At Fontenoy we had a number of guns (forty-seven it is said[1]), but again little is known of their services. Mr Gleig states[2] that in the returns of the Duke of Cumberland's force may be found six galloper guns, drawn by one horse, or two horses tandem, and adds that they were quite useless,—"a mere pateraro." The conduct of the allied artillery in general was bad. "Elle commenca par une cannonade éparpillée sur tout le front, qui peut bien inquiéter un peu les troupes placées derrière les ouvrage."[3]

The want of a corps of efficient drivers was severely felt at this time both in the English and in continental armies. The drivers of the English guns at Fontenoy deserted them early, and the march of the infantry was so delayed by their having to drag the guns, that these pieces were worse than useless.[4] Again at Falkirk, 1747, the drivers deserted the guns which had stuck fast in some heavy ground, and a number in consequence were lost.[5] And the flight of the drivers of a battery at Zorndorf caused even a greater disaster. "Une batterie Prussienne, attaquée par la cavalerie Russe, fut prise, et les charretiers, en se sauvant, traversèrent l' infanterie dans laquelle ils mirent le désordre."[6]

At Minden five brigades, 12-prs. and 6-prs., of the Royal Artillery were present,[7] and their conduct drew from the Duke of Brunswick a letter of thanks; and the batteries at Warbourg the next year appear to have behaved equally well, Captain Philips bringing up his guns at a gallop.[8] How this could have been done with effect while the gunners were dismounted is not clear, unless these guns were the gallopers mentioned by Mr Gleig.

Of the services of the Royal Field Artillery in the American wars which followed these campaigns it is difficult to give any detailed account, owing to the absence of mention of this arm in the dispatches of the Generals engaged, and the accounts written by reliable authorities.

Among the improvers of artillery between the Seven Years' War and the French Revolution, Gribeauval was by far the ablest. He completely separated field from garrison artillery, convinced by the results of the campaign of 1757, in countries difficult of access and abounding in bad roads, that a heavy field artillery is the bane of an army.[9] Yet even after his improvements Napoleon said, "Gribeauval has made great reforms, he has simplified much; but the artillery is yet too heavy, too complicated; it

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1 "England's Artilleryman," p. 12.

2 "Military History," p. 186.

3 Favé, p. 128.

4 *Ibid.* Drivers were not regularly enlisted in either the French or English services till the beginning of the present century. As late as the year 1800 Général Lespinasse was compelled to write of the French artillery; "Les équipages d'Artillerie ne pouvaient être plus mal entretenus que par les compagnies qui s'en étaient chargées dans les différentes armées, puisque partout les charretiers étaient continuellement sans pain, sans solde, sans habits, et leurs chevaux sans fourrage, sans fers, et sans harnais."—"Essai sur l'organisation de l'arme de l'Artillerie."

5 "England's Artillerymen," p. 13.

6 Favé, p. 140.

7 Aide-Mémoire to Mily. Sciences. Art. "Ordnance."

8 "England's Artillerymen," p. 22.

9 From an old French work called the "Manuel de l'Artilleur."

must be still further simplified, rendered more uniform, and reduced till it becomes perfectly simple."

Horse artillery was introduced into the British service by the Duke of Richmond in 1793, and has generally been kept in a state of efficiency, but the field batteries were still in a lamentable condition when the Duke of York's army landed in the Low Countries. The tactics of artillery were quite misunderstood, its value was unknown, and to save trouble the guns were told off by twos to battalions of infantry.[1] The result of this was that in case a battalion was hard pressed and forced to retire, its guns had to retire also. In an ordinarily fair country this might have been effected with ease, but in Holland, with its dikes and ditches and canals, it was a matter of no common difficulty for even a first rate field artillery, and how was it to be compassed by guns drawn by hired horses driven by Dutch wagoners (in smock-frocks), who walked by the horses with long whips?

As might have been expected many guns were lost, in spite of prodigies of valour performed by the artillery officers and gunners. But, as has been before remarked, no value was set on the artillery then. After the battle of Mouveaux,[2] 1794, in which a number of guns were lost, the disaster was communicated to the army in the following words :—

"Head Quarters, Tournay,
19th May, 1794.

* * * * * *

"In fact the enemy has little to boast of, but the acquisition of some pieces of British artillery."

This has been only surpassed by another commander, who 19 years afterwards lost his guns at Tarragona.

"They were of small value, old iron! he attached little importance to the sacrifice of artillery, it was his principle." "Strange indeed!" says Napier, "Great commanders have risked their own lives, and sacrificed their bravest men, charging desperately in person to retrieve even a single piece of cannon..... Sir John Murray's argument would have been more pungent, more complete, if he had lost his colours and pleaded that they were only wooden staves bearing old pieces of silk."[3]

But the misfortunes in Holland seem to have made no impression on even the artillery authorities at home, for we find Quarter-master Tate, of

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[1] This system is said to have been originated by Charles XII. of Sweden.

The battalion guns in the British service remained sometimes attached to the infantry in times of peace. Major Fry, r.f.p. R.A. told me that when a subaltern he was attached with a division of his battery to the 79th Highlanders for the last three years of the last century.

The inconveniences of battalion guns are fully dwelt on in the Emperor Napoleon III's. "Etudes sur le passé et l'avenir de l'Artillerie," Vol. IV. p. 183.

[2] Although the Duke of York claimed this victory, yet Sonham writing to Pichegru, 19th May, 1794, says,—"Le duc d'York doit à ses chevaux le bonheur de nous avoir échappé,"—From MSS. in the French War Office.

[3] "Peninsular War," Vol. V. p. 159.

the 8th Battalion, stating that in 1798, when he was reviewed by the Commandant at Woolwich, the guns with three horses each, driven by contract drivers on foot who wore short white frocks with blue cuffs and collars, and a long wagon whip over the shoulder, Capt. Spearman, garrison adjutant, observed to General Lloyd that it was impossible the movements could be quicker performed, to which the commandant assented!

Three years later than this, in 1801, cars were introduced to carry the ammunition and the gunners who hitherto had followed on foot. Yet in the expedition to Egypt in the same year, the guns were without any means of draught, and were dragged about by the sailors of the fleet till after the battle of Alexandria; which partially explains how it came to pass that at that battle "our field pieces were useless for more than an hour"[1] from want of ammunition.

In this year a corps of artillery drivers was also raised, but it is impossible to avoid concluding that the artillery was still a neglected service, when we read that, on the outbreak of Emmett's rebellion in Ireland, 1803, there was not a single round shot in the Dublin arsenal that would fit the guns.[2]

Matters do not appear to have mended much when the great struggle with France began in 1808; but to use Sir William Napier's words, "in the beginning of each war England has to seek in blood the knowledge necessary to ensure success, and like the fiends' progress towards Eden her conquering course is through chaos followed by death!"[3]

After the first eight days' campaigning in Portugal, during which time the combat of Roriça was the only engagement, Sir A. Wellesley was compelled to write, "I shall be obliged to leave Spenser's guns behind for want of means of moving them; and I should have been obliged to leave my own, if it were not for the horses of the Irish Commissariat."[4] Eight days after this and five days before the battle of Vimiero, no combat having intervened, he complained that "our artillery horses are not what we ought to have. They have great merit in their way as cast horses of dragoons and Irish cart horses, bought for £12 each! but not fit for an army that, to be successful and carry things with a high hand, ought to be able to move."[5]

Such were the horses, and the gun carriages were suitable to such animals; for one of the chief reasons that induced Sir Harry Burrard to stop the pursuit after the battle of Vimiero was that "the artillery carriages were so shaken as to be scarcely fit for service."[6]

In the hands of the Duke of Wellington the *matériel* of the Royal Artillery rapidly improved, and at the close of the war it was in admirable

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[1] Gen. Bunbury's "Great War with France," p. 112. As might be expected, the infantry at this battle felt the want of proper carriage for ammunition quite as fully as the artillery; and the 28th Regiment were reduced to such straits that they were compelled to pelt the French with stones!

[2] "Curran and his Cotemporaries." By C. Phillips, p. 280.

[3] "Peninsular War," Vol. IV. p. 150.

[4] Dispatch, Lavos, 8th Aug., 1808.

[5] Dispatch, Caldas, 16th Aug., 1808.

[6] Napier's "Peninsular War," Vol. I. p. 140.

order; but during the first campaigns in a country where, as a general rule, it was difficult to move,[1] and where forage was scarce,[2] the British gunners had to fight at great disadvantages against the French, after their fifteen years' experience in Italy and Germany.[3]

These remarks principally refer to the field batteries, for the horse artillery appears to have been excellent in every particular. Immediately before the battle of Waterloo, Marshal Marmont,[4] Duke of Ragusa, requested to be allowed to inspect a troop of Royal Horse Artillery, and the nearest troop, Lieut.-Colonel Webber Smith's was paraded for him. He inspected it most minutely, and, after asking all the questions that might be expected from an *Inspecteur Général d'Artillerie*, he finished by saying that the "equipment in every respect was very far superior to anything he had ever seen."[5]

Although the services of the artillery were so distinguished throughout the Peninsular and Waterloo campaigns, yet there was the best of reasons why no great exploit on a large scale was ever achieved by them, such as Senarmont's advance with 30 guns *en masse* at Ocána, or the massing of the 80 French guns during their retreat from Vittoria. That reason was the paucity of guns, and probably the 18 guns brought together at the passage of the Adour formed the largest battery massed in the field throughout the war.[6] Sir Augustus Frazer indeed says[7] that at Waterloo the artillery fought in masses as much as possible, particularly the horse artillery, but there is no record of the particulars, and the number of guns massed at any particular point could never have exceeded eighteen. These numbers sink into insignificance before those of the enormous masses used at some of the battles of Napoleon's wars, such as, Wagram, Friedland, Borodino, and Leipsic. But yet twelve guns and Kellerman's charge restored the battle of Marengo.

Between Waterloo and the Crimea, the next occasion on which the Royal Artillery appeared in the field in any force, there elapsed a long interval; but from the beginning to the end of the latter war the *matériel* of the field artillery was excellent.

Since that time rifled ordnance has been introduced and the importance of artillery has considerably increased, but without further experience it would be hazardous to say in what way the change will influence the arm at large.

To illustrate the foregoing remarks and give a general view of the

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1 The horse artillery at S. Pé had to "make fires to dry the roads;" and at the passage of the Bidassoa mounted officers were "sometimes for a hundred yards together up to the horses' bellies in thick mud stiffened by the frost."—Frazer's "Letters," pp. 334–384.

2 "Our horses have been starving.....we have been for many days without hay or straw or any substitute.....There is no grazing.....Our horses are eating chopped furze." *Ibid.* 375–388.

3 "Aide-Mémoire to the Mil. Sciences." Art. "Ordnance."

4 Marmont was an Artillery Officer.

5 Frazer's "Letters," p. 502.

6 *Ibid.* p. 430.

7 *Ibid.* p. 547.

progress of artillery during the last two centuries, the following tables, collected from various sources, are appended:—

Table

SHOWING THE VARIATIONS IN THE WEIGHT OF GUNS AT DIFFERENT PERIODS.[1]

Period.	12-pr.	9-pr.	8-pr.	7-pr.	6-pr.	4-pr.	2-pr.
	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
France. Francis I.....	...	...	...	17·8	...	...	10·7
" Henri II.....	...	...	22·3	...	...	...	13·4
England. Charles I.....	...	32	...	...	22·3 ($5\frac{1}{4}$-pr.)	13·3	6·2 ($2\frac{1}{4}$-pr.)
De Vallière's system, 1732.	28·5	...	18·7	...	...	10·2	...
Gribeauval's system, 1760.	16	...	10·7	...	...	5·3	...
English S.B. (present time).	18	13·5	...	...	6	...	...
Armstrong's system	8·5	6	...	...	3·25	...	...

The chief cause of the enormous weight of the guns in old times was the badness of the powder. In order to give the slow-burning powder time to be entirely consumed before the shot left the bore, the guns had to be made very long and consequently very heavy.

Table

SHOWING THE VARIATIONS IN THE WEIGHT OF GUN CARRIAGES AT DIFFERENT PERIODS.

Period.	12-pr.	9-pr.	8-pr.	7-pr.	6-pr.	4-pr.
	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
France. Henri II.	...	...	...	17		
De Vallière's system, 1732.....	15·7	...	13·2	...	...	11·5
English smooth-bores of the present day...	13	12	...	...	10·25	
Armstrong's rifled guns.....	12	12	...	...	6	

It must be remembered that the absolute weight of a gun carriage is by no means the total measure of its efficiency, but only one of its elements.

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[1] It must be borne in mind that formerly guns of the same calibre often differed very considerably in weight; as at present there are 13 kinds of 32-prs. of different weights and dimensions.

Table

SHOWING THE VARIATIONS IN WINDAGE OF GUNS AT VARIOUS PERIODS.

Periods.	Windage of field guns.
	in.
England. Charles I.....	0·25
England. End of 18th Century.....	0·2
English smooth-bores of present day	0·1
Armstrong rifled guns	0·0

The windage of smooth-bore guns may roughly be taken as a measure of their accuracy, the less the windage, the greater being the accuracy.

Table

SHOWING THE VARIATION IN THE CHARGES OF POWDER USED AT VARIOUS PERIODS.[1]

Period.	12-pr.	9-pr.	8-pr.	6-pr.	5-pr.	4-pr.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Charles I.....	...	7	...	...	4	
De Vallière, 1732	4·5	...	3·5	...	...	2
Gribeauval, 1760.....	4	...	2·6	...	...	2
English smooth-bores of present day	4	2·5	...	1·5		
Armstrong rifled guns	1·5	1·5	...	·75		

The charges used in Charles Ist time are taken from the "Gunner's Glasse," by William Eldred, master gunner at Dover, 1646. When he wrote, "corn" powder had taken the place of "serpentine" (i.e. non-granulated) powder; the former of which he says was "twice as strong" as the latter. It may therefore be concluded that the charges of powder used before his time were much larger than those given above.

I shall now compare an extract from Eldred's "Table of Randoms" with the modern range tables.

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[1] "The corning or granulating of gunpowder dates from this period, 1607, but as late as 1750 the proportions and method of manufacture were very defective, and the combustion comparatively slow and gradual."

In early times the powder was "about as effective as a common squib of the present day..... and it is not too much to say that the composition which we understand by that name dates only from" 1815, when Sir W. Congreve patented his new mode of manufacture.—Mr H. Latham on early breech-loaders. Journal of the United Service Institution. Vol. IX. No. 34.

Table of the Ranges of Field Pieces at different periods.

	Nature of gun.	Weight.	Charge.	Elevation.										
				P.B.	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
		cwt.	lbs.											
a	15-pr. whole culverin ... (Eldred)	35	8	460	630	900	1120	1330	1460	1770	1990	2120	2430	2650
a	18-pr. S.B. gun ..... (present time).	38	6	350	690	990	1270	1500	1710	1890	—	2130		
b	12-pr. light brass gun (end of 18th cent.)	12	3	...	600	816	1063							
b	" medium do	18	4	...	705	973	1190							
b	" S.B. gun ..... (present time).	18	4	300	700	1000	1200	1400	1600	1800				
b	" Armstrong gun .	8·5	1·5	...	680	1087	1330	1650	2086	2220	2500	2760	2970	3230
c	9-pr. demi-culverin ... (Eldred)[1]	32	7	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400
c	" S.B. gun..... (present time).	13·5	2·5	300	680	960	1190	1400	1590	1750				
c	" Armstrong gun ...	6·1	1·1	...	...	770 (2°6′)	...	...	1628 (5°3′)	...	...	...	...	2673 (10°2′)
c	" (8 lbs. 13 oz.) can-on de 4 rayé ...	6·5	1·1	...	...	762 (2°6′)	...	...	1495 (5°3′)	...	...	...	...	2340 (10°2′)
d	5-pr. Saker (Eldred) ...	22·3	4	360	440	720	910	1090	1270	1450	1630	1810	1990	2170
d	6-pr. light brass gun ... (end of 18th cent.)	6	1·5	...	587	825	950							
d	" medium do	12	2	...	775	1003	1444							
d	" S.B. gun ..... (present time)	6	1·5	200	620	890	1100	1280	1450	1600				
d	" Armstrong gun...	3·25	·75	260	580	880	1170	1460	1680	1960	2180			

[1] The ranges given for this gun cannot be correct, giving as they do equal increments of range for equal increments of elevation.

The ranges of guns at the "end of the 18th Century," given in the foregoing table, are taken from a MS. note book belonging to Major Fry, r.f.p., R.A., and dated 1806. When he copied these ranges, they had been in use for some years.

[Since making the foregoing table, Brigadier-General Lefroy, R.A., has told me that there still exists in the R.A. Library, Woolwich, a number of range tables by General Borgard, the first Colonel of the Regiment, dating back to the middle of the last century.]

THE INTRENCHED CAMP AT FLORISDORFF.

BY LIEUT. J. P. NOLAN, R.A.

LAST summer's brief campaign revealed a want of foresight on the part of the Austrian government for which it has received just censure; still upon one score, namely, the construction of an intrenched camp in front of the capital, the military advisers of the Kaiser may fairly claim to have exhibited more than ordinary prudence.

The works constituting this camp were commenced before the opening of hostilities, and while a reverse such as Konigratz, appeared, at least to outsiders, to be a most improbable contingency.

Their object is the protection of Vienna, the centre to which the officials who administer the various provinces forming the Austrian empire look for orders, and where its arsenal, a grand one, even when judged by the Woolwich standard, is situated.

Vienna has 530,000 inhabitants, it is built on the right bank of the Danube, but is distant a mile and a half from that stream, it has outgrown its old *enceinte*, and is now an open town.

To completely girdle it with fortifications would demand much time and money, however its position offers peculiar facilities for cheaply covering it against an army advancing from the north, by the erection of defensive works on the left bank of the Danube.

Two fine bridges built on piles connect the capital with Florisdorff, a suburb of insignificant size on the left bank, one of these is for carriages, and is 500 yards long, the other 400 yards lower down is used by the northern railway.

The Danube is here a broad, deep, and rapid stream, subject to sudden risings.

The Florisdorff bridges derive their great importance from the fact that no other bridge crosses the river nearer than Krems* above, nor below nearer than Theben and Presbourg.

In 1805, Murat gained the Florisdorff bridge for Napoleon, winning it by a daring stratagem executed at great personal risk. This feat was considered to have had a great influence on the ultimate fortunes of the campaign of Austerlitz.

In that year Vienna fell without resistance; Napoleon made it the base of his manœuvres against the combined Russian and Austrian armies, and his line of communications crossed the Danube at Florisdorff.

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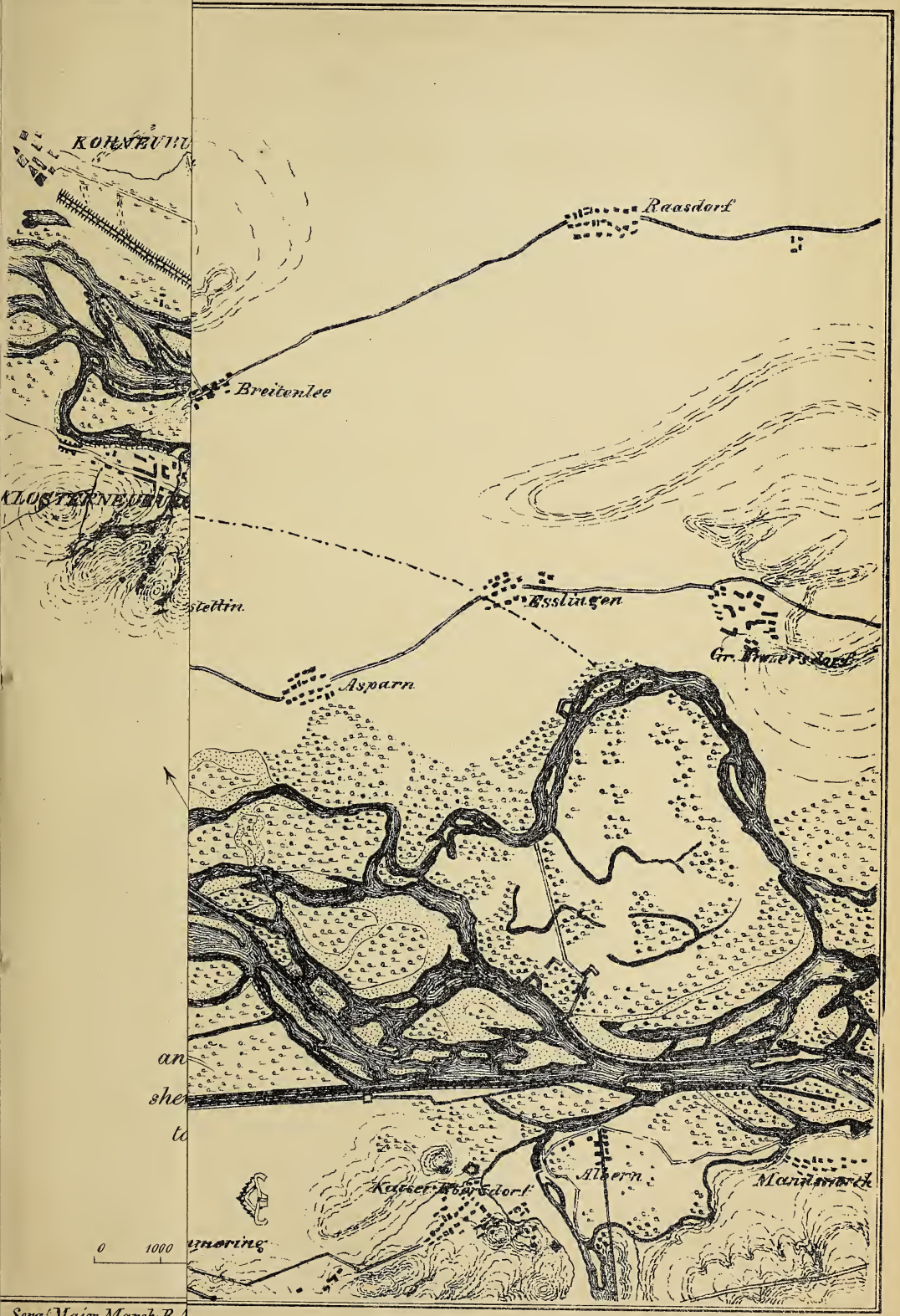
* Krems and Presbourg are each distant 40 miles from Vienna; all bridges below the capital are built on boats.



Serg.t Major Marsh R.A

Lith.ographed at the Royal Artillery Institution

VIENNA

and Country northward shewing Works erected in 1866 to protect the Capital

Rough Scale

0 1000 2000 3000 4000 5000 Yards

Serg.t Major Marsh R.A del

Lithographed at the Royal Artillery Institution

In 1809 the bridge was destroyed, Vienna yielded when it found that Napoleon would enforce his threat of bombardment, but the Archduke Charles succeeded for more than six weeks in forbidding the passage of the river; when this was ultimately forced at Lobau, Vienna formed again Napoleon's base of manœuvres, he re-established the bridge of Florisdorff, and it became the most important point on his line of communication with the capital.

A few months since it seemed probable that the passage of the Danube and the importance of the Florisdorff bridges were about to receive a fresh illustration. After the great victory gained on the 3rd July by the Prussian king, no course promised him politically or militarily, morally or materially such decisive advantages as an early occupation of his enemy's capital.

Had no intrenched camp existed at Florisdorff, three means of entering Vienna naturally presented themselves;—

(1) To bombard the town from the left bank until its inhabitants might induce the Austrian commander-in-chief to withdraw from it his troops.

(2) To force a passage of the river near Vienna.

(3) To steal one at a considerable distance above or below that city. In the actual state of affairs, neither of the two first courses could be pursued until the Austrians had been again defeated in an intrenched position, where their artillery would have had the great advantage of fighting at the very gates of its arsenal.

It may seem that the works would not have interfered with the third plan, but although they could not do so directly, indirectly they greatly increased the difficulty and danger of its execution.

(1) They enabled the Austrians to watch the left bank.

(2) The bridges which they covered would probably allow the Austrian general, while the Prussians were engaged in the passage of the river, to pit on either bank the whole of his own army against a portion of the enemy's.

The general plan of the works which thus afforded the Austrians another chance of saving their capital, is simply an outer chain of large detached redoubts, and an inner line made up of two completely separate *têtes de pont*, the larger formed of connected redoubts, covers the Florisdorff bridges, the smaller was in front of a military boat bridge thrown across at Stadlau.

The outer chain consists of thirty-one redoubts, on the left it extends along the heights of Bizamberg, in the centre it passes in front of the villages of Stammersdorff and Leopoldstadt, and on the right again touches the Danube near the isle of Lobau.

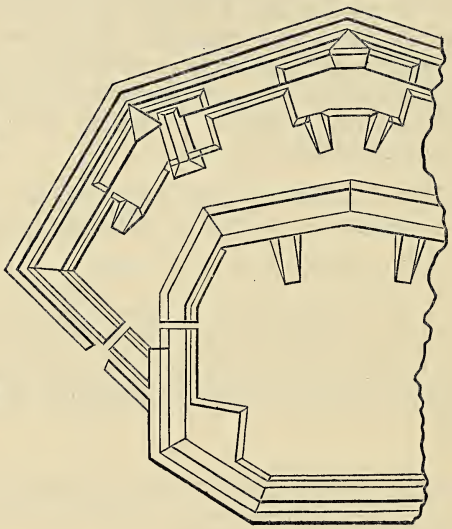
The ground to the left is high and mountainous, sinking at the left centre into hills, to the centre and right the country is very flat, and is dotted with numerous and substantial villages which often are just within the line of defence.

The distance of the chain from the Florisdorff bridges is never less than 4500 yards; from Vienna never less than 6500.

In the left centre where the redoubts command the Florisdorff and Brunn road, the distance apart from salient to salient is 500 yards, and some of the redoubts are retired so as to lend considerable assistance by their flanking fire to those more advanced.

In the flat ground the redoubts are 1000 yards apart, here there are sometimes employed small intervening open batteries.*

Werk No. 14 in Exterior Chain.



Scale $\frac{1}{1800}$

Each redoubt consists of two front, two flank, and two rear faces, the gorge being closed by the interior retrenchment.

A plank bridge across the ditch, and a brick revetted cut in the left rear face give entrance to the redoubt, the passage can be closed by a wooden door.

The retrenchment has nine faces, but might practically be called a square redoubt with the corners cut off, its parapet is all in earth, it is joined to the main work by a loopholed brick wall which sweeps the ditch of the flank of the retrenchment.

This latter is entered through two brick revetted cuts in its flanks, also furnished with wooden doors.

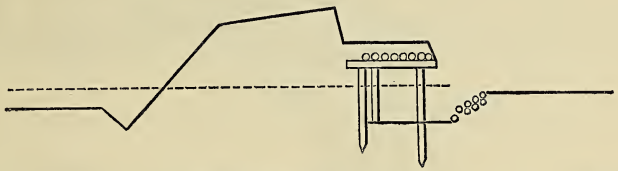
The leading feature of the retrenchment is that its front faces have sunk under their terrepleins, galleries, open to the rear in the centre, closed near the extremities.

In one redoubt instead of a retrenchment, there were three mounds of earth with covered galleries at their rear, the openings between the mounds were closed by traverses placed checkerwise.

The principal points to be noticed in the profile, are that the parapets of the exposed faces are 19 ft. thick, those of the retrenchment and protected

* I think it is intended to add more redoubs on small batteries near Leopoldstadt.

faces 12, that the berm is small and sometimes does not exist. Werk 14 has a brick revetted counterscarp, the other redoubts have no revetments either for escarp or counterscarp, but this appears to be due to want of time for their construction. The ditches are narrow, and seldom swept by flank fire, the glacis are insignificant.



Section of Retrenchment. Scale $\frac{1}{75}$

In general there are places for five guns at the salient and for three at each shoulder; sometimes also positions are reserved for guns at the angles where the flank meets the rear face.

The tread of the banquette is generally 3 ft. in breadth expanding into a terreplein of 30 ft. in breadth where it is meant to employ artillery.

The parapets are raised about 3 ft. by bonnettes, in front of the positions for guns.

In the retrenchment there is on each flank a cheap modification of a haxo-casemate to hold two guns, the embrasures of which are directed so as to sweep the ground behind the rear faces of the main work.

At the time of my visit (the first days of October) no guns were in any of the works.

For revetments and for steps to facilitate access to the banquettes and to the superior slope of the parapet (in order to fire into the ditch) fascines were much used; hurdles were often employed as revetting, gabions seldom, and only for embrasures.

The magazines are in traverses near the guns, two which I entered were triangular in section, and had a passage of rectangular section; these and the covered galleries struck me as being well protected from horizontal fire, and from perhaps the effects of 8″ mortar shells, but could have been entered by heavy mortar shells.

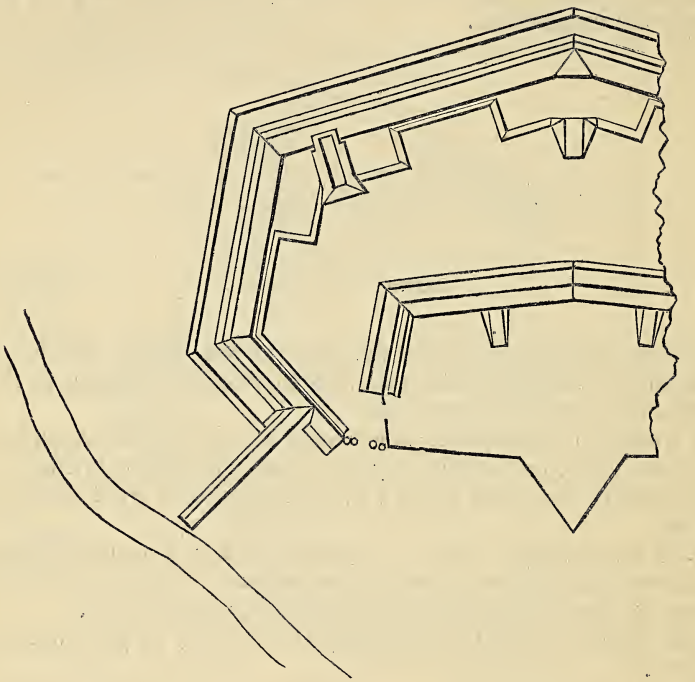
Part of the earth to form the parapets had been taken from the interior of the works.

Many of these latter contained pumps.

As an inner line two *têtes de pont* to cover the permanent bridges at Florisdorff, and a boat bridge thrown across for the occasion at Stadlau have been erected.

I only visited the former, it consists of eight large closed redoubts, of five closed redans or *flèches* and of two small open batteries, the whole connected by a ditch and parapet, behind the latter runs a sunken and good road 22 ft. broad, except between Werks 7 and 8, which are joined by a trench, of ordinary siege profile. The *tête de pont* is at an average distance of 1800 yds. from the bridges and of 6000 yards from Vienna, its total circumferential length is 7000 yards, or four miles.

Each main work consists of two front, two flank, and two rear faces, the gorge is closed by a loopholed brick wall, or in one or two cases by palisades.



Redoubt of Inner Line. Scale $\frac{1}{1200}$

Each redoubt has a retrenchment similar to those of the outer chain, save that the rear faces are of brick.

Palisades connect the main work with its retrenchment.

The parapet is only 16 ft. thick, the ditch is 12 ft. broad, the counterscarp is in all cases revetted, except in Works 1 and 8, where the ground is marshy; the ditch for half its breadth is studded with pointed stakes 18″ high.

The *flèches* are a little retired, their artillery fire sweeps the ground in front of the main works, their faces are about 40 yards long, room for five guns is generally left at the salient, the gorges are closed by palisading, the ditches never revetted, contain generally palisading which slopes towards the counterscarp.

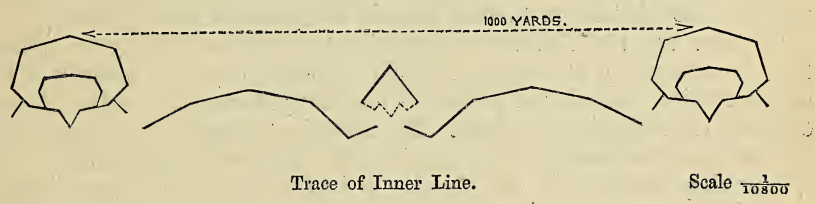
The connecting parapets are 8 ft. thick, the ditch is insignificant, a good sunk road runs in rear, above the bottom of which the crest of the parapet is $9\frac{1}{2}$ ft.; the interior slope of the parapet is not sufficiently steep to permit a soldier firing comfortably over it.

Those faces of this parapet which flank the main redoubts contain each two guns.

In the outer line the redoubts were placed near the main roads, and railways, in the inner line generally on them, new roads being constructed to lead round the flanks of the works.

In one part of the line a railway embankment was made to do the duty of a connecting parapet, care was taken to direct a flanking fire of artillery along its front, this was effected by the erection of a small battery.

The embankment also formed one side of Werk 6. Brick revetting was pretty freely used in this inner line. Nos. 1 and 8 being constructed in ground likely to be inundated, contained a good deal of board revettings.



Trace of Inner Line. Scale $\frac{1}{10800}$

In the outer chain of redoubts where the works are thickly studded together, as across the Brunn road, they are capable of offering a most formidable resistance, but in the plain about Leopoldstadt they seemed to me to be too much apart.

I had this summer an opportunity of examining at Wibourg, Finland, an intrenched camp, commenced in 1863-4, when a collision between Russia and the Western powers was deemed possible, and which, though still in process of construction is in a very forward state; its plan fairly embodies the leading points approved of by General Todleben. As it is easier to contrast one system with another than to pronounce decidedly on the value of either it may be interesting to note those features which the Austrian and Russian intrenched camps have in common and where they differ.

The Wibourg redoubts were 450 yards apart, about the same distance as the more closely packed Austrian ones, in addition however the Russian camp possessed a good battery between each pair of redoubts, the former being so placed as to sweep the ground in front of the latter which were also protected by the guns of the nearest main works.

The trace of the redoubts were in both cases much the same; neither seeking to defend their ditches by a parapet fire, they were generally able to secure their front faces from enfilade without being obliged to have recourse to traverses.

The Russian works, unlike the Austrian, had no retrenchments. It was intended to close their gorges with brick walls as has been done in the inner line at Florisdorff. The parapets in the two cases were of the same thickness. The Russian berm was 7 feet broad, the Austrian only one.

At Florisdorff the ditches were narrow, shallow, and without flank defence. At Wibourg both escarp and counterscarp were roughly revetted with stone; *caponnières* of wood were to have been built had the works been suddenly wanted, now brick ones will be made communicating by vaulted passages with the interior of the redoubt, a fork of the same passage allows the garrison to sally into the ditch.

The Austrian glacis was a mere nothing, the Russian was almost as large as in a permanent fortification.

In front of the Austrian guns an additional height was given to the parapet by earth heaped upon the superior slope. The terreplein of the Russian rampart, (for these works had a low rampart), was $7\frac{1}{2}$ ft. below the crest of the parapet, and an earthen platform about 18″ high was raised to elevate the gun.

The magazines at Florisdorff were in traverses, at Wibourg beneath the terreplein and covered by 7 ft. of earth.

Free access to, and free circulation on the ramparts was much more carefully provided for in Finland than in the redoubts near Vienna.

To sum up, the Russian system develops better artillery fire, allows a freer movement of the garrison within the work, owing to breadth of berm and large size of glacis the parapet is less easily damaged, the ditch is a real obstacle, the magazines are safer. The Austrian redoubts have the advantage of a retrenchment and of the cover galleries afford to the garrison.

Speaking roughly, if the Russian redoubts had their *caponnières* and magazines constructed in wood, the expense of the two systems would probably be much the same.

EXTRACT

OF A

MEMORANDUM BY THE COMMITTEE OF ARTILLERY, ON A SYSTEM OF HARNESSING WITH THE *BRICOLE** (BREAST STRAP), OF WHICH TRIAL HAS BEEN MADE IN THE ARTILLERY OF THE IMPERIAL GUARD.

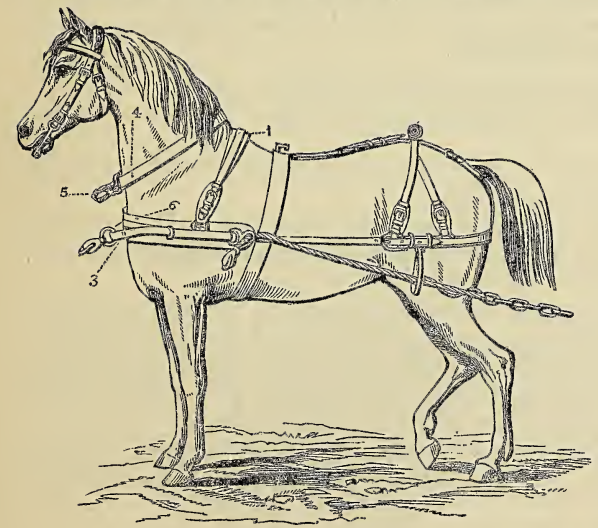
[Translated from the French, by Major Goodenough, R.A.]

NOTE BY TRANSLATOR.

THE following papers were kindly furnished to me in 1865, from the Office of the Committee of Artillery at Paris, at the request of Major-General Lord F. Paulet, C.B., whom I accompanied on an official visit to the Camp of Chalons that year as one of his Staff.

It may not be generally known that a system of harnessing with breast harness was adopted in 1858, and is now in general use in the French artillery service. The advantages of the system as indicated in these papers and as specially set forth in the Report from Mexico, which is the last of them, appear to be universally appreciated by the officers of the French artillery.

The interest of the subject discussed in these papers, which is perhaps equalled by that of the examples they afford of the thorough and painstaking system adopted in testing a proposed improvement, is sufficient apology for their introduction to the notice of my brother officers.



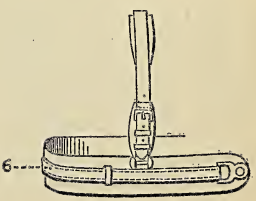
1 *Bricole* and wither strap [*dessus de col*].

3 Breeching [*plate longe*].

4 Neck stall supporting pole [*calleron*].

5 Buckling strap for do [*courroie d'agraffe*].

6 "*Lay*" [*blanchet*].



Harness of off-wheel horse. French Artillery.

* A *bricole* is properly a sling or loop as used in man harness, or to support a basket or pedlar's pack from the neck or chest.

I am indebted for the drawing to the courtesy of a gentleman of the Emperor's household to whom, from his knowledge of both languages, I applied for explanation of the technical expressions relating to harness.

Sitting of the 19th February, 1858.

The Minister of War has, in a dispatch bearing date the 4th February inst., referred for examination by the Committee the report of a Commission assembled at the School of Artillery of Versailles, which was charged with the making of some experiments on a system of harnessing with the *bricole*, submitted by Commandant Laffitte.

This system consists of the *bricole* or *breast strap* proper, supported by a wither strap, and completed with all the other parts of the harness as in use in the service with the exception of the collar.

For the wheel horses, the breeching is in one piece and a neck stall serves to support the pole by means of a buckling strap.

The *bricole* and the neck strap are made each of one piece of leather, folded on itself down the middle, inside to inside, so as to form two thicknesses between which grease may be inserted with the object of keeping these parts pliable.

A "*lay*" is applied to the *bricole*, and is sewn down its length to strengthen it.

The two edges of leather cut square which form the lower edge of the breast strap having caused some galls to the horses' chests, the Commission at the close of its experiments, recognized that to remedy this defect, it was necessary to let the inner flap overlap by three or four millimètres and to bevel off the edges of both substances.

The price of the bricole is 15 fr.
That of the neck strap is 5 fr.

The breeching can be made up with the two portions of that now in the service, connected by means of a splice.

Preliminary experiments had been made by Commandant Laffitte at the end of 1856, and during 1857, with a section of field artillery, harnessed with the *bricole*.

This section after having gone through the march to, and the manœuvres at the Camp of Chalons, had subsequently been worked under the direction of the Commission formed by the General Commanding the Artillery of the Guard and had been compared with those equipped with ordinary collar harness in the draught of 24-prs. on different kinds of ground.

It was ascertained that not one of the horses employed had been rendered ineffective for a single day. The Commission then undertook four series of comparative experiments.

* * * * * *

In the fourth series of experiments two 24-prs. with teams of ten horses each, one harnessed with the collar and the other with the breast strap, were made to go up once a day, for three days running, a steep ascent in sandy ground of the most difficult nature.

The horses had to put forth all their strength, they were halted from time to time to recover their wind.

In all the trials, the teams performed their tasks, but without its being possible to give a preference to one or other of the systems. At the same time the Commission were of opinion that in the greater number of cases the simultaneous action, which is difficult to obtain with a team of ten horses, and yet is necessary to overcome a serious obstacle, required more attention and knowledge on the part of the drivers in the case of collar draught, than in the case of breast draught—if a horse throws himself singly into the collar he recoils, with the breast harness he throws himself into his work more willingly, keeping in draught until the moment when, the other horses make their effort, and the obstacle is overcome.

The result of the whole of the experiments shews that the wither strap and neck stall have caused no galls.

In examining the results of the first series of experiments at first separately and then in comparison with those of the 2nd and 3rd series, one is led to conclude that the breast strap itself does not gall horses accustomed to its use whose skin has become gradually hardened, while galls incurred by horses not so accustomed are generally slight, and capable of easy cure, even under continued work.

The fourth series of trials which had for its object the observation of the comparative effects of the two systems when employed with heavy weights, in bad ground and with sudden jerks, rather than in continued draught, leads to a conclusion contrary to received ideas, of a certain advantage in the breast harness over the collar. We may find the explanation of this in the fact of the horses working better together, even although the work obtained from each horse be perhaps with the new system less, than with the old.

The advantages which would result from the adoption of the breast harness are numerous, facility of stowage, of transport, of fitting to horses of all descriptions, of manufacture, of repair, the better assured preservation in store, uniformity of size, economy in providing and keeping up supply, rapidity in harnessing and unharnessing, lightness and elegance in appearance, and preservation of the fore part of the shabraque.

Programme of experiments to be made on a system of Draught by means of Bricoles (breast straps).

* * * *

ART. 4.—As soon as the harness with breast straps has been received, each regiment will exècute without interruption, and with the designated equipment, four preliminary marches of from 25 to 30 killomètres, within the radius of the garrison, and after one day of rest, four field days (manœuvres) with the batteries equipped; two of which to be on the ground of the polygon, and two as far as possible on rough ground.

ART. 5.—The battery will then perform as early as possible a march of ten to twelve days' journey including return, with field equipment; the march will be performed two-thirds at the walk, and one-third at the trot.

The route will be chosen so as to offer the greatest difficulties and the greatest varieties of road.

Art. 6.—Four days afterwards the battery will execute another march with siege equipment.

In order that these two series of trials should be thoroughly comparative, it will be necessary that the first itinerary should be as far as possible followed in the second march.

The equipment for this trial for each half-battery will be as follows, viz.:—

24-pr. on carriage, travelling position	1—8	horses.
16-pr. on carriage, travelling position	1—8	"
24-pr. on carriage, spare	1—4	"
12-pr. on carriage, boxes packed	1—6	"
Carriage pattern, 1833, empty	1—2	"
Wagon, siege, empty	1—2	"
	Total 6—30	

Each demi-battery will take with it besides two spare teams.

The march will be made at the walk. During the march, the harness of both systems will be placed in the stables at the halting places, as is the ordinary custom. Under all other circumstances they will remain in the open air as at the bivouac.

Art. 7.—The comparative value of the two systems will be studied under all circumstances of marching and manœuvring: it will be observed how they act, during heavy exertions on the part of the horses, and whenever it is necessary to increase the number of horses in draught.

Account is to be kept up of galls and sores incurred by use of either system, and of the facility of effecting cures on the march.

Particular attention is to be directed regarding the ordinary preservation of the harness in both systems, and on the nature, the facility, and the cost of repairs.

The Commission will study the effect of the two systems as to the wear and tear of the horses, and it will particularly observe the action of the neck stall in descents and deep ground.

Extract of Minute of the Committee of Artillery on the comparative experiments made in different Corps of the Artillery with the Harness with the Bricole, *and the Service Harness with the Collar.*

Séance of the 23rd July, 1858.

* * * *

Each of the regiments belonging to the schools before named was ordered to make up a battery of manœuvre composed half of teams with breast harness, half of teams with the collar. It was recommended that each of

the demi-batteries should be as much as possible under the same conditions, as regards the strength and description of the horses, and the expertness of the drivers.

The different batteries thus organized were to be subjected during fifteen days under the superintendence of special Commissions, to preparatory exercises destined to habituate the horses to the use of the *bricole* (breast strap), and were then to execute successively four marches of from 25 to 30 kilos, and four field days, with carriages.

To these preliminary exercises succeeded more serious trials consisting of ten days' march with field equipment packed, a third of the distances being done at the trot.

Finally, after some days of rest the same teams were made to recommence the same itinerary, this time with siege equipment.

The analysis of the reports shews that the points of comparison on which the attention of the different Commissions has been particularly directed in order to appreciate the relative value of the two systems of draught are as follows:—

(1) Facility of draught.

(2) Galling of horses.

(3) Wear and tear to horses.

(4) Facility of adjusting the harness, and of harnessing and unharnessing.

(5) Facility of carriage and of storage of the harness.

(6) Maintenance and repair.

(7) Influence of inclement weather.

FACILITY OF DRAUGHT.

Minute of the General Commanding the Artillery of the Guard.

In an additional series of comparative trials executed on sandy and steep ground, it was observed that with teams with breast harness it was easier to ensure the traces being stretched before starting, because the horses leant without fear on their breast straps, while on the contrary, the horses refused to throw themselves beforehand into the collar, the traces were imperfectly stretched, and at the putting of the carriage in motion there would ensue a violent jerk, during which many of the horses would rear up, particularly the off horses.

The force of these jerks was such that two swingletrees of excellent wood were successively broken by the teams with collars.

The collar and the breast harness gave nearly the same power of draught, but the draught with breast harness is more free from jerks.

* * * *

Minute of the General Commanding the Artillery in the 12th Military Division.

The horses with breast harness do not appear to have found the draught more heavy, or to have experienced more fatigue on the march than those with collars, and whenever similar conditions are met with to those in which the experimental battery found itself, marching on level or slightly undulating roads, the results obtained show that one could employ indifferently the breast strap or the collar, but if great obstacles were to be overcome such as may be met with on a campaign, perhaps so powerful a draught could not be obtained with the breast strap as with the collar.

WEAR AND TEAR TO HORSES.

Regiment of Horse Artillery of the Guard.

During a march of ten days' journey in a hilly country, the Commission has established that in going down hills, the neck stall does not at all fatigue the horses. In ascents the counter weight of the (gun) carriage is such that at the worst moments the hand can pass easily under the neck stall.

During the experiments with siege equipment, the greatest attention was given to the fatigue experienced by the horses in ascents, and nothing could be discovered to the advantage of either system, although the exertions of the horses were very great.

1st Regiment of Artillery.

The horses returned to Grenoble in perfect condition, as well and as strong as before setting out, after traversing 309 kilos, of which 102 were at the trot.

It has been proved that the *bricole* interferes less with the breathing than the collar.

7th Regiment of Artillery.

The promenades, manœuvres, and marches at which the Commission has been present, have not given results so decisive as to enable it to judge decisively of the influence of the two systems on the wear and tear of the horses. The Commission is nevertheless forced to avow that neither in ordinary conditions of draught nor during violent exertions has it remarked that the *bricole* interfered with the breathing or with movements of the shoulder, as there was reason to fear.

MAINTENANCE AND REPAIR.

1*st Regiment of Artillery.*

The maintenance of the *bricole* is easier than that of the collar, the replacing of parts liable to get damaged is easier in the breast harness system than in the collar system.

7*th Regiment of Artillery.*

The seams which unite the doubled leather of the body of the breast strap became rotted in a short time by the sweat with which they were saturated, and in consequence the repair of the breast straps became much more costly than those of the collars.

The Commission considering the difficulty of remedying the defects of the breast straps, concludes that the collar is preferable to it in respect of strength.

* * * *

15*th Regiment of Artillery.*

The two systems of harnessing give like results in all the circumstances of service, but at the same time, slight superiority remains due to the breast strap, in respect of the number of galls which have been of easy cure, and which never for an instant prevented the horses from being put to.

The system of harnessing with *bricoles* presents certain advantages which cannot be gainsaid and of which the principal are the following: its simplicity, its lightness, its lower price, finally, the facility with which it is fitted, which permits one single pattern of breast strap to adapt itself, so to speak, to every kind of horse, whilst with the three sizes of collars in use in the service, it is only at the cost of constant care and with great difficulty that one arrives at finding collars suitable to the particular shape of each animal.

In consequence, the Commission concludes unanimously that the harness with breast straps should be preferred for field artillery.

For siege equipment the Commission is of opinion that the collar should be retained, founding this opinion principally (in the absence of trials pushed to extremes and in very difficult ground saturated with rain) on the opinion of postmasters and agriculturists.

Opinion of the Colonel Director.

The marches which the Commission has performed have afforded long and difficult slopes to be overcome, the heat was extreme and the dust distressed the columns. The loads drawn have been generally very considerable, (one mortar and bed weighing 4500 kilos, fifteen 36-pr. guns and 22-pr. howitzers weighing 3600 kilos, eight 30-pr. guns of 3600 kilos, &c., &c., &c.).

The *bricole* having successfully undergone these trials and its advantages being besides incontestable as regards lightness, economy, preservation and carriage, preference is given to it over the collar.

In spite of the favourable results of the experiments of which the analysis has just been furnished, the majority of the Commission do not think themselves in a position to propose the immediate adoption of the breast harness system; they demand that the experiments should be continued with a view of testing the durability of the breast strap, and the manner in which it behaves in the bad season of the year under the influence of wet weather and severe cold

Considering the importance of the question, and in presence of so radical a change in the mode of draught of the horses of the artillery, the Committee shares the opinion advanced by the greater number of the Commissions.

Minute of His Majesty the Emperor.

It seems to me in reading this memoir that I see reproduced the discussions of Vallière and De Gribeauval on the advantages and disadvantages of iron and of wooden axletrees. Iron axletrees have prevailed in spite of certain incontestable advantages of those in wood because the iron axletrees had in spite of some inconveniences yet still greater advantages. Therefore why wait longer for useless experiments which will doubtless prove that the *bricoles* have also their *disadvantages*.

Nothing in this world is perfect, but as it is proved that the *bricole* is more economical, is more easily kept in order on service, that the horses draw well, that, if they are killed, the harness is more readily removed, what would one wish to know more before adopting it?

I give my opinion therefore in favour of immediate adoption.

(Signed) NAPOLEON.

Extract of a Minute of the Committee of Artillery on a Report relative to the conservation of Artillery Harness in the Campaign in Mexico.

Séance of the 3rd March, 1864.

* * * *

The *bricole* permitted to be put into draught together—little mules from the hot country, whose height did not exceed 11 hands 1 in. and the mules of New York, whose height was 16 hands 1 in.

It produced none but slight galls which healed of themselves easily on the march. * * * This motley character, in the harnessing, and the simultaneous employment of almost all known methods of draught have furnished the officers of the artillery with an opportunity of making comparisons between them which is perhaps unique.

Our regulation harness has undergone under these circumstances a trial which may be considered decisive, and which gives special value to the

following observations, recorded in the reports of the captains of batteries, and of companies of the military train.

* * * *

Owing solely to the adoption of the *bricole*, we have been enabled to put in to our teams in Mexico, animals unequal in size, form, and aptitudes, which necessity had made us accept as remounts.

Thirteen pairs of old collars have been issued to the 1st battery, 9th regiment; twenty pairs of new collars of the *guard*, and fifteen pairs of American collars have been given to the train. The bad service they rendered exhibits the embarrassment in which the army would have found itself, if it had been still equipped with its old system of harness. These collars were altered repaired and furnished with pads in vain, they still continued to cause galls.

The battery of the 9th regiment was obliged to get rid of its collars after the taking of Puebla.

The companies of the train only kept theirs for want of *bricoles*. These on the contrary have only caused few and trifling galls. The mules from New York, hot and untrained young animals suffered most, but all became cured spontaneously and quickly during the march.

The cleaning and greasing of the internal part of the breast strap are easy, and the leather has lost nothing of its suppleness during the campaign.

The parts of the breast strap which undergo wear are,

(1) The fold of the body of the *bricole* which gets cut in the middle of the chest in consequence of the rubbing of the neck stall; this inconvenience could be avoided, for some batteries have afforded no examples of it, whilst in others it occurs in every *bricole*.

(2) The *lay* of the *bricole* which becomes worn and gets unsewn in consequence of the friction of the breeching.

* * * *

The damages incurred are of trifling importance.

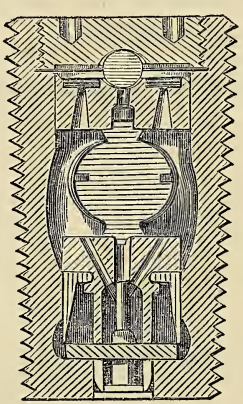
PETTMAN'S GENERAL SERVICE PERCUSSION FUZE.

BY CAPTAIN VIVIAN DERING MAJENDIE, R.A.

ASSISTANT SUPERINTENDENT, ROYAL LABORATORY.

PETTMAN'S General Service Percussion Fuze* differs from his Land and Sea Service fuzes mainly in an arrangement for ensuring the action of the fuze in rifled shell.† It has been explained that although the Sea Service Pettman's fuze is available with muzzle-loading rifled shell, it cannot be depended upon to act in breech-loading rifle shell, because owing to the ball lying in the axis of rotation and to the absence of any lateral movement of the shell in the bore—any lateral concussion, the steady plug and ball cannot always be depended upon to disengage.‡ The same limitation applies to the use of the Land Service fuze.

The arrangement by which the action is ensured in the General Service fuze is as follows: The upper side of the steady plug and the lower side of the top plug are cupped out in the centre to receive a small plain brass§ ball, which when situated in the cups keeps the plugs a short distance apart. The cups are made slightly larger in diameter than the ball to diminish the liability of the latter to adhere to either plug from corrosion or other cause. The ball thus only touches each cup at one point.



* Approved 19th May, 1866, W.O.C. 10 (N.S.), § 1235.

† The land and sea service Pettman fuzes were described at page 74; and upon this description the present account of the general service fuze is based, to avoid repetition of much description common to all the Pettman fuzes.

‡ Vide p. 82.

§ 70 parts copper, 30 zinc.

On the upper side of the steady plug is cut an annular groove or recess into which is pressed detonating composition.*

To give the composition a more secure hold, the bottom of the annular recess is roughed by a number of small grooves formed in it. Over the top of the detonating composition is fixed a thin copper† washer sufficiently strong to prevent action taking place on the shell striking water with a high velocity, although not strong enough to interfere with the proper action of the fuze when the shell strikes a ship's side or similar hard substance with a low velocity. Two conical fire holes pass vertically through the steady plug from the detonating composition.

The other points in which the construction of this fuze differs conspicuously from that of the other Pettman fuzes, are:—

(1) The cone plug, which is no longer coned at the top although it retains the name, has in addition to the central fire hole, two inclined fire holes passing into the tube. Its construction is otherwise the same as that of the sea service fuze.

(2) The parts of the fuze are supported not by a lead cup but by a copper "suspending wire."‡ The support afforded by the wire is not ultimately greater than that which is afforded by the lead cup in the other fuzes, that is to say, no greater shock is required to shear it than is required to crush the lead cup, but the wire not being affected by the small shocks to which a fuze is subject in transport, is on the whole more reliable than a lead cup, which being neither rigid nor elastic, yields little by little to a succession of such small shocks, sufficiently in the end to deprive the parts of the fuze of the necessary support. The wire passes through the tube of the cone plug and rests upon the bottom of the fuze. No action can take place until the wire is broken.

The lower part of the central hole of the tube is sufficiently enlarged to prevent it from being closed by the suspending wire; above the suspending wire the hole is contracted.

(3) The support of the parts of the fuze being dependent upon the suspending wire, the lead cup which the fuze contains performs only the secondary functions of the same cup in the other fuzes, viz. it serves to rivet down the cone plug after discharge and prevents re-action.§

(4) Externally the general service fuze is conical without any projecting shoulder. It is screwed to the general service fuze hole gauge|| all the way down.

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* The same detonating composition as is used for covering the detonating ball in the land and sea service fuzes, vide p. 77. The composition however is pressed dry into the plug.

† The copper is ·008″ thick.

‡ The wire is ·087″ thick.

§ The form and size of the cup are slightly different from those of the land and sea service cups. It weighs from 102 to 114 grs. The considerations as to the purity of the lead and the precise limits of weight of the cup which, as explained at p. 77, note 1, apply to the cups of the other fuzes, scarcely apply to this one, at least not to the same extent. They are however properly observed.

|| 14 threads to the inch, right-handed, cone increasing 1 in 9·375. The size of the frustrum is 1·95″ in length. 1·006″ in diameter at small end. 7·213″ at large end.

Two slots are cut in the top of the body to serve as key holes. The "key iron, fuze and plug general service" is used with these fuzes.

In other respects the construction of the general service fuze is similar to that of Pettman's sea service fuze, the arrangements which have been adopted in the latter fuze for bringing the sensitiveness of the fuze within the exact limits prescribed for naval service* being embodied in the general service fuze. The fuze has thus the enlarged chamber and the copper disc over the ball,† it has also the solid base with fire hole closed with a cardboard disc, and the groove round the lower part of the body for the lead cup to expand into and fix itself.

The general service fuze is stamped on the top with the numeral, number of thousand, and month and year of issue.

Action.—The action of this fuze fixed in a spherical shell is under all circumstances the same as that of the other Pettman fuzes, except that the shock of discharge has to shear the suspending wire instead of merely crushing a lead cup.

But under the condition which may arise in a B.L. rifle shell,‡ of the detonating ball not becoming disengaged from its supports, the special arrangement in the head of the fuze becomes indispensable to its action.

Under these circumstances what happens is as follows:—The plain ball having by the descent of the steady plug on the shock of discharge been thrown out of its cup supports, it occupies during the flight of the shell a position between the top and steady plugs immediately over the detonating composition of the latter. On the impact of the shell end on, the steady plug is thrown violently forward against the plain ball, the blow sufficing to explode the detonating composition in the plug, the flash from which passes through the fire holes in the steady plug to the detonating ball or directly to the cone plug.§

The general service fuze is intended for use with all naval spherical shell and all M.L. or B.L. rifle shell having the general service fuze hole or adapter, and when a sufficient number of fuzes and adapters are made it will entirely supersede the sea service Pettman's fuze.‖

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* For a definition of those limits, see p. 80.

† The ball is the same as that of the other Pettman fuzes. In manufacture somewhat closer limits are observed, the limits of weight of the uncovered ball being 130 to 140 grains, instead of from 125 to 140 grs. as laid down for the other fuzes. The weight of the ball covered is the same as that of the sea service fuze, viz. from 148 to 160 grains.

‡ Vide p. 82. In those B.L. shells in which a lateral concussion does take place the condition defined in the text could not arise.

§ Action will ensue whether the detonating ball be ignited by the flash from the steady plug or not. The inclined fire holes in the cone plug by providing a passage for the latter makes the ignition altogether independent of the detonating ball.

‖ See on the subject of the introduction of the fuze and the gradual supersession of the S.S. fuze. W.O. Letter, 5th July, 1866, $\frac{75}{12}$.

ERRATA.

page viii., line 7 from bottom, *for* "grateful a tribute," *read* "graceful a tribute."

" xi., line 11 from bottom, *for* "1779," *read* "1799."

" 293, last line of note, *for* "7·213″," *read* "1·213″."

ON THE

GEOLOGY OF GIBRALTAR,

WITH ESPECIAL REFERENCE TO THE RECENTLY EXPLORED CAVES AND

BONE BRECCIA.

BY LT. ALEXANDER B. BROWN, R.A., F.R.A.S., F.G.S.

THE principal mass of the Rock appears to be a grey dense primary marble, the beds of strata varying from 20 to more than 40 ft. in thickness, with subordinate beds of shale, and chert (specimens No. 13* from Windmill Hill, and No. 9 from above that place) with rubbly sandstone dipping in a direction from E. to W. at an angle of about 37°; there are several casts of marine shells, chiefly terebratulæ, found in it belonging to the oölitic period; the Rock extends 2½ miles from N. to S. and is about ¾ miles in breadth, the greatest elevation being about 1470 ft. The soil on which the town is built, the Alameda, &c., is siliceous red sand, this forms the largest bank of arenaceous matter on the western side of the mountain, and consists of several particles of crystallized quartz, nearly colourless in themselves but of an ochreous or red colour in mass, by reason of the red argillaceous earth which adheres to them. The sand bank on the eastern side of the mountain is composed of small particles of the calcareous rock, the whole of a whitish grey colour, there also appear to be some raised beaches of siliceous deposit partly broken by the fall of the crumbly calcareous rock, &c. On the south of the red sand the soil is variegated, it is a light loose mould of a fertile quality, and is found irregularly scattered in the fissures, and crannies of the rock, which in the wet season becomes of a saponaceous sliminess. In other places the mould is mixed with sand, and in other spots the soil consists of a stiff marl or species of fullers'-earth, and may be looked upon as alluvial.

Mass of the rock, primary marble.

Alameda of red sand.

Calcareous sand slope of eastern beach.

Soil alluvial.

There cannot be a doubt that at one time the Rock was the bed of agitated waters, and only arrived at its present position by successive upheavals, manifested by the numerous pot holes found in different parts. On Windmill Hill which was doubtless a sea-beach at one time, I have found some of these pot holes filled with coloured

Pot holes.

* The Nos. refer to those on specimens in the R.A. Institution Museum.

flints, and argillaceous earth formed with stalactitical calcareous spar into a breccia, some other pot holes are nearly 1000 ft. above the present sea level, they being formed in the solid rock by the attrition of pebbles set in motion by the rapidity of a river or currents in the sea. On the western face of the rock there are beds of strata consisting of a blackish brown or ferruginous coloured earth, seen in abundance near "The Old Man's Garden" above Windmill Hill; slate and limestone slate (specimens No. 1 and No. 5) are found covered with a deposit of this earth, and dark shale impregnated with manganese, existing midway between that place and "The Old Man's Garden" with fine quartz crystals, also pieces of limestone covered with dendrites; and farther south are found greenish flints, imbedded in a shining reddish clay.

Slate and shale.

Near Rosia there is a breccia found, composed of fossils and dark greenish calcareous rock combined with a yellow coloured cement (see specimen No. 6). On the shore on the western face of the Rock and parallel to its axis, there are a series of beds of highly indurated shale (see specimen No. 3), nearly vertical, and lying over the stratified limestone beds. There are many caves filled with Osseous Breccia, the bones having in the course of time been washed into the large fissures of the Rock, and imbedded in a calcareous concretion of a reddish brown ferruginous colour, highly indurated, and of an earthy fracture; these bones are of various animals, quadrupeds, and birds of different sizes mixed "pell mell," and accompanied by shells of snails, fragments of rocks and of calc spar, in a kind of breccia; doubtless they have been carried off the surface by the heavy rains into the fissures, and after having undergone the permeating action of water, which in course of long periods of time has deposited calcareous matter, and thus cemented the whole together in the form of an ossiferous breccia. I found in many places a very hard rock containing throughout it bones of different sizes, and land shells, with pieces of limestone.

Breccias.

This breccia has been constantly forming, and contains both large extinct mammalia, and also bones of various existing species including human remains (see specimen No. 12 from Poca Roca Cave, and specimen No. 11 from Windmill Hill Cave), more breccia and of greater variety has been found near Rosia than anywhere else. The bones found some 30 years ago consisted of the Ox, Deer, Sheep, Rabbit, Water-mouse, Horse, Ass, Snake, and various birds and shells of the land species. On taking a chemical analysis of some of the bones we found them to consist of phosphate of lime, and the interstices of carbonate of lime; many were found at Rosia Bay, and at the north side of the Rock, more lately however they have prevailed at Windmill Hill. Amongst the various breccias that I found in different parts of the Rock, was one of land shells about 500 ft. above the sea level near Willis's Guard.

Bones of animals found thirty years ago.

Another remarkable deposit occurs which commences somewhat above the 3rd Europa Advance Battery and strikes northward, past Martin's Cave, to that vertical piece of the Rock that joins the "blown sands" of Catalan Bay, near The Brown Cave. It is a minute conglomerate composed of broken shells (see specimen No. 4) cemented together by stalagmite, small fissures and crevices being found

Minute shell breccia.

in it. It is one of the most important geological deposits, and consists of pieces of limestone besides fragments of small shells; these shells are both so small, and so waterworn and fractured as to defy identification, but I have lately obtained some perfect fossils in it from a similar though much coarser conglomerate in the "galleries;" it bears considerable resemblance to millstone grit, and having in some places a red tinge from the presence of oxide of iron. It is very tough and hard, although the coarser kind is liable to crumble when continually wetted. It is used to a great extent for lining the embrasures, and attains a thickness in some places of nearly 300 ft.; somewhat beyond Martin's Cave it exists at a height of nearly 650 ft.

Fossils in coarser kind of minute shell breccia.

Mussels have been found, also, in a fissure, by Mr Smith, at a height of 34 ft.! above the sea level, perfectly preserved. This careful observer to some extent unravels the clue to the history of the numerous deposits, which he ascribes to the broken, and dislocated condition of the fundamental limestone rock, which bears the appearance of comparative recent disturbance so frequently repeated, and of such magnitude as to exceed that of any other European locality.

Mussels.

Besides the coarser kind of shell breccia (specimen No. 4) obtained from the galleries, there abounds also a kind of pudding stone (see specimen No. 10) and a great variety of limestone formations thereabouts; masses of calc-spar are found mostly more or less imperfect in their crystalline form, the most perfect mass I obtained (is specimen No. 7 in the case) near Poca Roca Cave.

Pudding stone.

The limestone generally is a compact rock varying in colour from a dark ash grey and snake colour (see specimens No. 3), to nearly white (see specimen No. 2), it is intersected throughout by ramified caves or vertical fissures, the angle of stratification varying at different parts, and reversed at the opposite extremities of the promontory, as well as in two or three places along the crest of the hill downwards. The greatest varieties of colour in the limestone I find to exist at Rosia, from whence Nos. 2 and 3 specimens are taken, as well as the greatest variety of breccia (see specimen No. 6 from Rosia).

Limestone of variable colour.

Near to Forbes' Barrier was found, about the same time as the bones of the ox, deer, &c. a skull which was in possession of the Geological Society of Gibraltar, and afterwards presented by them to the Museum of the Soldiers' Home; considerable doubts were at one time entertained as to the nature of the skull, but upon the dismemberment of the museum, being believed to be a human one of low organization, it was sent to the celebrated anatomist Professor Busk, F.R.S., who pronounced it to be undoubtedly that of a human being of the lowest known organization somewhat analogous to the "neanderthal," his opinion being at the same time supported by the late lamented Dr Falconer, V.P.R.S., and several other scientific men, and when, early in October, 1864, examining with Professor Busk the slope of the old quarry of Forbes we found the matrix in which we believed the skull had been imbedded, which was a raised beach of about 100 ft. above the sea level, and which was seen everywhere to be cropping out of the limestone slope, the inner portion of the beach being covered with broken pieces of calcareous rock, and the outer being broken off, disjointed masses being carried down by the

Human skull.

crumbling masses of limestone; many subsequent visits confirm me in the opinion of this being the veritable matrix. It is scarcely necessary to add that this is one important proof of the immense antiquity of the famous skull. "This human skull" say Dr Falconer and Mr Busk, "yielded by 'The Rock,' appears to us to point to a still higher antiquity of man than even those found in the valley of the Verère in the south of France. In fact, it is the most remarkable and perfect example of the kind now extant."

Elephant's tooth.

In scarping the ancient sea cliff at Europa Point another raised beach was found, at the height of 50 ft., and 20 ft. higher a third, in the last the molar tooth of a fossil elephant of the extinct species (*elephas antiquus*) was found, with sea shells adhering to it, many years ago by Mr Smith. This tooth was handed over, like the skull before spoken of, to the Gibraltar Scientific Society, and by them to the "Soldiers' Home," this having been lost for countless days, with no trace of its existence known, save the statement of Mr Smith, was found by the author, after much labour, amidst the debris of the "Soldiers' Home." The tooth is of great importance as a link in the bright chain of fossil remains to be hereafter spoken of, in the "new finds" of the more recently explored caves.

It is much to be regretted that among so many officers, and some of them scientific men, these important relics which initiate us into the mysteries of by-gone times, and show to us as ages roll on the various and successive changes that the earth has passed through, and which lead us to true philosophic notions of what may hereafter take place in the course of years, should be so little regarded, or cared for; that men should, day by day, and hour by hour, tread over this vast mass of mineral wealth and knowledge, without one wish to make that knowledge their own, and thus to assist science in its vast speculative strides, and in its earnest search after truth.

Caves, Windmill Hill.

First fissure.

The caves of Windmill Hill, &c. next demand our attention, "the flats" themselves are about 400 ft. above the level of the sea; on the north end of these flats stands the military prison, and in the month of November 1862, when enlarging the same, and making excavations for a new tank, Mr Brome the governor of the prison came upon a fissure of about one foot long, and five inches wide, between two large blocks of limestone. On the following February, after blasting out a portion of the solid rock some small bones were found in a small fissure, under some dark mould, in a disordered state; while carrying on these works on St George's day, a rock covered with stalactites together with a boar's tusk, pottery and shells were found, and evident traces of a spacious cavern. Mr Brome, whose zeal manifested itself during these operations, directed the prisoners to collect carefully every bone, &c.; a great deal of red loam was next found filling up the fissures, while dark earth and hard loam with small pieces of charcoal, also bones of animals, birds, &c. separated from one another the large blocks of limestone which now presented themselves. In the latter part of July a large passage was discovered 45 ft. deeper, having a roof of 30 ft. in height; 17 ft. lower another cavern, now called "Victoria Hall," 20 ft., lower another fissure, and again descending a larger one, the sides of which were covered with fantastic stalactite formation, many resembling small hollow glass tubes and translucent, about the diameter of a common quill,

and from 4 to 10 inches long. Imbedded in the clay at the bottom of the fissure were found bones of birds, fish, marine shells, flints, &c. At the lowest depth of the cave 200 ft. below the surface, or about 200 ft. above the sea level, a current of air can be felt ascending through the fissure, the temperature indicated by the thermometer, here, was 66° Fah., on the 21st August 1863, in the cave, that outside being 78° Fah. (in shade). Human remains were found scattered about in all directions, very few whole, much less an entire skeleton, some stained a bluish black colour, also animal remains petrified, and otherwise, as well as stone implements, arrow heads, anklets, querns, and pottery, the latter are rudely made, unburnished and formed without the aid of the potter's wheel; some land and marine shells were found adhering to the sides of the cave as in life, others incrusted with stalagmite, also waterworn pebbles of sandstone, and limestone. The extent of the cave in a S.W. direction is about 350 ft. and in a vertical one 220 ft. below the surface; hereabouts there is a large cave the height of which was found to be about 80 ft., near which was seen a large stalagmite column 7 ft. in circumference, and 9 ft. in height, with a crack running throughout which probably occurred at the time of displacement. We see therefore that the "Genista* Cave" consists of a set of interesting and ramified vertical fissures, that the principal fissure situated below the intended tank of the prison, consists of four superimposed chambers, connected by vertical passages, to a depth of about 220 ft., that the passages were for the most part, filled with ossiferous deposit, though the fossil remains predominate near the surface as "osseous breccia" imbedded in ochreous earth, "having regard to the large number of human bones and quantity of pottery exhumed from the upper chambers on the alternate supposition of its having either been inhabited by savage man, or a place of sepulture, that no adequate means of access to it by a surface entrance has yet been detected," and that the displacement of the large stalagmite pillar, shows that some violent disturbance has taken place in the cave, at a late period in its history, (specimens Nos. 11, 17, 18, and 19, come from this cave).

Human remains.

Windmill Hill Cave, now called Genista Cave.

Professor Busk, and the late lamented Dr Falconer, upon examining the bones sent to them, determined upwards of 20 species of mammals, belonging to the Rhinoceros, Equus, Sus, Bos, Ibex, Capra, Cervus, Lepus, Mus, Felis, Hyæna, Canis, Ursus, Meles, Phoscœna, some extinct and others now living, besides birds and fish; many skulls of ibex, "in one case," said Dr Falconer, "we have been enabled to re-unite the fragments and detached upper epiphisis into the perfect tibia of a rhinoceros." The bones, or broken fragments of bones are rarely in contact, being separated by the interposition of more or less of the indurated reddish mud, so highly impregnated with iron, many of the bones are covered with dendrites, and other evident traces of manganese are found, some have the appearance of being scorched by fire, many of being bleached by the sun, the bones evidently belong to the pliocene and present periods, no trace of miocene deposits are anywhere found on "the Rock."

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* So called after its finder Genista, being the Linneal appellation for Broom.

Animal life on "the Rock" in olden days.

The fossil remains of the Genista Cave establish *beyond question* that "the Rock" was formerly either peopled by, or the occasional resort of large quadrupeds like the Elephant, Rhinoceros, Deer, Ibex, Wild Horse, Boar, &c. which were preyed upon by Hyænas, Leopards, African Lynx and Serval, that the remains were transplanted by any violent diluvial agency from a distance is opposed to all the evidence of the case; the manner in which they were introduced into the caves, now known as Genista, was probably by the bones that were not acted upon by the atmosphere, being strewed in the various hollows, and afterwards swept by the action of the heavy rains together with shells and stones into the fissures, and subsequently solidified into a conglomerate mass by calcareous infiltration. "That elephants frequented the Rock," said Dr Falconer, "is proved by a valuable specimen of the molar tooth of an extinct species (*elephas antiquus*) discovered (as before stated) in a sea beach at Europa Point, by Mr Smith of Jordan Hill, and afterwards recovered by Lieut. Brown of the Royal Artillery," that hyænas dwelt upon "the Rock" is also manifested by the fact that in addition to the numerous bones, *coprolites* of hyæna brunnea were found in large quantities in the "Genista Cave" (these animals exist now no higher than the Cape of Good Hope), large numbers of ibex must have existed, as Dr Falconer estimated the remains he examined to be two or three hundred; that the Rock was then to a great extent clothed with tropical vegetation, like the corresponding limestone mountains on the African coast are now, is so legitimate an inference as to be hardly open to rational doubt, although at present scarcely food is found for the goats, much less for cows, or larger animals. This may be easily accounted for by the fact that vegetation tempers the heat, attracts moisture, and greatly increases the fall of rain.

Connexion between Europe and Africa.

As it is highly improbable that these wild animals could have crossed the Straits, the legitimate inference is that there was a connexion between the two continents at no very remote period.

Flint implements found with human remains.

Human remains were found in great abundance in the upper chambers of the cave, about 30 or 40 individuals accompanied by stone implements of the polish stone periods, broken querns and a large quantity of pottery, also marine shells of edible species, many of the bones belong to widely different epochs, and were probably buried there by human agency; new caves on Windmill Hill are still adding to our store of knowledge, and increasing the stock of our valuable animal remains, upwards of 20 species of mammalia enumerated above have been found in these various caves, and added to the mammalian palæontology of Gibraltar, I doubt not that, in the new caves and fissures which seem to undermine Windmill Hill, under the active superintendence of Mr Brome, further important petrifications may be brought to light, numerous human skulls of various dates have been already found, in fact, one cave seems to have been on old burial place in by-gone days, also other bones combined with the same kind of flint implements, and pottery as before; some have produced petrified bones including *petrified jaws* of a human being, which were found deposited under solid stalagmite.

Human jaws petrified.

Martin's cave.

Leaving Windmill Hill and turning our steps upwards we come to "Martin's Cave" on the south-east side of "the Rock," this seaboard cave excavated by the sea, and evidently sea-worn, was dis-

covered by a gunner of the Royal Artillery, some years ago; it is about 600 ft. above the sea level, although becoming daily less, as from constant observation, we know that the Rock is *gradually* sinking, and at some future period the eye-sore of Spain, and oft bone of contention of Europe, may disappear beneath the sea, as it has been known to have done before by many geological proofs, and the nautical charts of future generations may mark its place only as a dangerous shoal or reef.

Gibraltar sinking.

At the height of this cave and some 50 ft. above may be seen the celebrated minute shell breccia before mentioned (see specimen No. 4), and near here is a waterworn conglomerate of some extent, manifestly at one time a sea beach, thus affording another proof of the force of upheaval the Rock has undergone.

Poca Roca Cave.

On the north side of the Rock is Poca Roca cave; in excavating and blasting the rock, near this cave late in 1864, to obtain a suitable ground for a small gun park, a large fissure was found, filled up with bone breccia, the bones being various, but chiefly of small animals, such as ibex, rat, deer, &c., &c. much the same as those found some years before near the galleries, hardly any being so ancient as those of "Genista Cave" or so important, from this fissure (specimens No. 8 of minute bone breccia, No. 12 of land shell breccia, and No. 20 of a deer's tooth) are taken; this cave seems to have been formed by the violent concussion that rent "the Rock" mid-way between the signal station and rock gun battery, near to Middle Hill, evident marks of the disturbance being found.

St Michael's Cave.

Now lastly turning to the long celebrated, and far-famed cave of St Michael, we find traces of the disturbance extending from the south side of the signal station, through St Michael's Cave, passing a small cave near the "Old Man's Garden," down to Windmill Hill, the Genista Cave being probably formed by the same violent force of upheaval, as the axes of fracture of all three are nearly identically in a line; wishing to know if this celebrated cave, which consists of a long fissure, could afford us any further information on the bone breccia question, and also wishing to solve certain doubts, and the truth of certain rumours respecting this cave, I determined upon a careful exploration, with such instruments as I deemed requisite for the purpose.

Visits to St Michael's Cave between the months of Apr. and June,'65.

On the 21st April accompanied by Capt. Jerome, and Dr Jackson of the 86th Regiment, and Serjt. T. Hanson, and Bomb. R. Smith of the Royal Artillery, &c. the first exploration was made. On arriving at the "Grotto" the difficulties and labours became so great, that my party which had been gradually thinning, now consisted, besides myself, of Serjt. Hanson and Bomb. Smith, to these two intelligent n.-c. officers who assisted me from time to time in most of my subsequent explorations, and scientific investigations in this cavern, much of the success which attended our labours is due; we found the depth, from the entrance of the cavern (which is about 937 ft. above the sea level), to the floor of the "Grotto" (the lowest part) to be 265 ft., and to the "Prison" 245 ft., the greatest depth also to the spot now known as "Hanson's Cave" to be 257 ft., while that of "Brown's Seat" at the extreme end was somewhat less being 242 ft., the distance of

this spot from the entrance, measured along the main route, being 1700 ft. or thereabouts, while that of the "Prison" is 1230 ft.; all preceding explorers had arrived at the conclusion that the "Prison" was the extreme end of this cavern, and it was only by means of great labour, and care, that we were enabled to prove the contrary. The axis of fracture, the lines of stratification, and above all the currents of air which were manifest in several fissures, at the end of the "Prison," together with the sound, convinced me that there were other large caverns in this wonderful fissure, beyond the one we were in, so examining with the aid of hammers and crowbars two or three of the most likely spots (denoted by the current of air), we finally came upon a passage which by dint of some labour we were enabled to enlarge to a sufficient size to permit a man to pass through, upon doing so my opinions were verified by finding a cavern larger than any of the former (perhaps about 1600 cubic ft. in space), with passages, and two other caverns beyond; at the latter, though we were effectually stopped, as instead of the ordinary stalactites we came upon vast masses of the primary limestone, without any prospect of an outlet of any kind whatever; no current of air was noticeable at any of the fissures at the extreme end of the cave, both the geological formation and the sound &c. indicated that we had come to the termination of it. This visit took place on the 17th June, 1865.

New caverns found beyond supposed end of cave.

The whole exploration of this cave was executed with the greatest care, the many difficulties and dangers in passing through the narrow passages, some of which had to be traversed at full length on our backs, where neither the hands nor the legs could be of any service, the only means of locomotion being the shoulder-blades caused it to be a somewhat hazardous task; one of the passages, not the smallest we went through was 11 inches in the highest part, and 22 inches in extreme width, of the form . The extreme beauty of the stalactites and small caverns fully repaid us, however, for our labour. The instruments we took down were two barometers, two compasses, geological hammers and chisels, thermometers, these together with the aid of magnesium wire, and other lights, crowbars and ropes enabled us to form a pretty correct survey of the fissure, each visit taking between 11 and 12 hours.

The cave abounds in stalactites, and stalagmites, and in several places we found large quantities of pure water, in other places we found a kind of loose crumbling semi-stalagmitic limestone. The same with pieces of stalagmite and limestone covering the sides, also limestone breccia highly coloured with oxide of iron, this principally exists in the passages and holes leading out of the "Grotto," carefully examined on the 8th May; we descended into these holes, and found them in some places 60 or 70 ft. deep, also the red crumbling limestone breccia is found in the fissures near the entrance of the cave. Notwithstanding the most careful examination we found *no trace of bone breccia nor any bones* in the cave, excepting the leg and wing bones of small birds; *at the extreme end of the cave* where the foot of man had never before trod, these were found petrified and half imbedded in a stalagmite floor, in a small water course, they having been evidently washed down from the outside of the cave (supposed from a hawk's nest), through some exceedingly

Petrified bones of birds alone found.

narrow fissure, the larger masses of limestone existing here prevented any possibility of finding the source from whence the bones had sprung.

Bones washed into the entrance of the cave found by Capt. Risk, R.N.

Near the entrance of the cave were found by Capt. Risk, R.N. in 1844, some bones imbedded in the flooring of the cave; large quantities of bones of goats, rabbits, rats, &c. probably washed in from the rocks above, by the heavy rains through some of the numerous fissures, also Osseous Breccia (?) We found however, as stated before, with the exception of the bones of small birds, washed apparently through the roof, *no traces* of organic remains of any kind, though we followed the supposed marks left by Capt. Risk, as well as of others. The cave is filled with stalactite pillars; masses of rock and stalactites now present ingress to some other branches, near the entrance, said to have existed in olden times, this fissure is believed to extend almost as far as the north front. So many absurd reports exist with regard to the cave, and mostly by people who have never visited it (except in the entrance part) as to warrant my saying they should be received with great caution. The most remarkable features of the cave appear to be, the remarkable purity of the water it contains, and also of the air; though a limestone cavern, and extending at least 1700 feet (or $\frac{1}{3}$ of a mile) underground, no trace of carbonic acid gas can be found, the current of air that was apparent throughout the main fissures and passages being strong enough in some places to extinguish a candle; also its equiable temperature being about 62° F., while that of the water was about one degree higher, caused perhaps (to adopt the heat theory of Professor Tyndall) by percussion of the constantly falling drops on the surface of the water, with the water itself, the extreme beauty of the stalactite pillars, and their hardness, some of which are hard enough to strike fire with steel. Pieces of some of the best (see specimens, No. 14, from the "Prison," No. 15, in form of leg, from Hanson's Cave, and No. 16 from Brown's Bath) I have added to the case of specimens which I trust will aid in illustrating this paper, and be acceptable to the R.A. Institution; and lastly the fact of the magnetic needle being slightly deflected in some places, showing evidently strong traces of iron in the cave.

Cave free from CO_2.

The annexed table, I think I may say, is as nearly correct as possible, being verified by frequent observations, it will aid in showing the heights of the different stages, and the direction of the main fissue, &c.

I may further add that bottles were left at the "Grotto," the "Prison," and at "Brown's Seat," (the extreme end of the case) with papers bearing the inscription of our names, and dates of visits, for the guidance of future explorers.

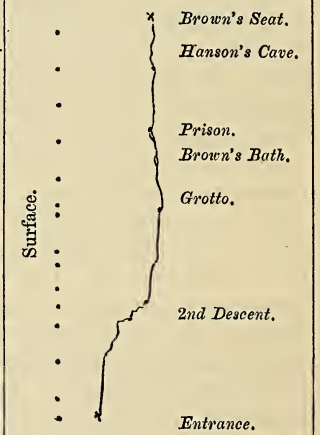
Should this paper fall into the hands of some who take an interest in geology, I trust it may not be altogether unacceptable, as illustrating to a slight extent that Rock which is so rich in the evidences of by-gone days, and in links of the mighty chain which connects us with the past history of the world.

Table

SHEWING HEIGHTS AND DISTANCES OF DIFFERENT STAGES.

B, barometer. T, thermometer (F). C, compass.

St Michael's Cave.	B.	C.	T.
	°	°	°
Entrance to Cave	28·915	142	62
1st Descent	29·022	48	64
2nd Descent	29·033	242	63
3rd Descent or "Grotto"	29·190	122	62
4th, "Smith's Hole"	29·155	204	63
5th, "Brown's Bath"	29·110	94	62
6th, "Prison," originally supposed end of cave	29·131	94	62
7th, "Hanson's Cave"	29·161	90	62
8th, "Brown's Seat"	29·145	92	62



SHELLS FOR RIFLED FIELD GUNS.

BY LIEUT. J. T. BARRINGTON, R.A.

THE object of this paper is to discuss, however feebly, the relative advantages of common and shrapnel shell as projectiles for modern field artillery, with respect to the influence of rifled guns and breech-loading small arms upon military tactics, and the modifications which may, in consequence of their use, be introduced in the dispositions of troops.

Some years have now elapsed since the introduction of rifled artillery, and opportunities have not been wanting, of testing its action and judging of its effect on the field of battle. The experience hitherto gained, has however, taught but little more than the bare fact of the superiority, in range and precision, of this description of ordnance, over smooth-bore guns and howitzers, an amount of knowledge which it was not necessary to go to the battle field to obtain. The probable effects of the introduction, when it should become general, on the tactical formations, and dispositions of troops, have been freely discussed and foretold, but until the events of the recent war in central-Germany startled Europe, a practical test, under favourable circumstances, of the soundness of the predictions, has been wanting. This has chiefly resulted from the gradual adoption of the new principle by military states, and the consequent existence of a period of transition, during which, rifled and smooth-bored ordnance have been unequally pitted against each other on the field of battle.

A notable instance of this is afforded by the Franco-Austrian campaign of 1859, which served principally to shew the important advantage conferred upon the French army by the superior range of its rifled artillery. This one-sidedness has also been a marked feature in our own recent colonial wars, and, added to the general inferiority of our opponents, it has detracted much from the value of the experience gained, and perhaps tended rather, from the certainty of victory, to an over-estimation of the advantage possessed in rifled ordnance *per se*, and to a depreciation of precautionary measures, which become of great importance, when the advantages in arms are equally balanced. The late great American civil war, in which the contending armies learned to a great extent the art of war in fighting, has added little to the military knowledge of Europe, as regards the effects of the use of arms of precision and rapidity of fire, upon the established tactics of highly disciplined armies. This has resulted from the general crudeness of the operations, the untried character of the organizations, and the prevailing wildness of the country. We learn however, that the art of rapidly creating entrenchments was a daily study, as regularly practised as the lighting of the bivouac fire, or the

cooking of the evening meal; that battles were sanguinary almost beyond precedent; and that arms, highly destructive from their rapidity of fire, were largely used. It may be inferred, that the two former of these circumstances were, in great measure, the results of the latter, and in this respect, their consideration bears upon the matter under discussion.

On the third of July 1866, the day of the decisive battle of Königgrätz in Bohemia, were for the first time presented to view, two European armies of vast proportions, fully and about equally armed with modern rifled artillery. This occasion may therefore be cited as the first, on which the action of this nature of ordnance has been developed, under conditions favourable to a consideration of it, uninfluenced by incidental circumstances. The battle of Custozza, fought in the jaws of the Venetian quadrilateral, although the opening conflict of the war, preceding that on the upper Elbe in point of time, is unworthy to hold this place, from its inferiority as a battle, both in design and in the numbers engaged, and from the imperfect information given to the world of its details.

It may be interesting, so far as our information extends, to consider the dispositions of the artillery in the battle of Königgrätz, and the duties which were imposed upon it.

From the letters of military correspondents, it is gathered, that the Prussian army was equipped with about 700 field guns for the attack, and the Austrian army with an almost equal number for the defence. Probably nearly the whole of this enormous force was brought into action during the day. As regards the amount of judgment displayed in the disposition of the Austrian batteries, the accounts are somewhat conflicting, but they were posted, with more or less skill, to sweep the approaches to a position, which, from its salient contour, was not the most favourable, as regards the defenders, to a concentrated artillery fire. This Austrian disadvantage was evidently an advantage for the Prussians, whose line, overlapping the position, rendered a converging and concentrated fire a natural condition. There is reason to believe, the ground was not wanting in natural obstacles, and such features as facilitate a stout defence, and to these, so far as the time at the disposal of the Austrian engineers would permit, were added lines of breastwork and batteries to protect the guns, and redoubts for the strengthening of points held by the infantry. Whatever the strength of the profile of these entrenchments, they added no doubt greatly to the security of the position, and to the difficulty of the task to be performed by the Prussians in their direct attack. The Prussian guns when engaged, were necessarily in a great measure exposed, having to seek the enemy on his own ground, and open fire from points, of which the ranges had previously been ascertained by the Austrian artillerymen. This latter disadvantage was gradually neutralized, owing to the power usually possessed by an assailant, of placing a superior number of pieces in battery, for a concentrated fire upon successive points of a defender's position. The advantage of cover on the side of the Austrians was not so easily overcome, and to this probably may, in a great measure, be attributed the fact, that the Prussians failed to dislodge their adversary from the centre and left of his line, until the outflanking of the right wing rendered the position untenable. Thus much for the manner in which the artillery was disposed on the field of Königgrätz. This has been chiefly referable to the Austrian army, which was deliberately posted for the defence

of the ground. The dispositions of the assailants were, as a matter of course, regulated by the plan for the defence, and were undeveloped until the hour of battle arrived.

The active duties performed by the artillery are, on the other hand, to be gathered principally from a consideration of the operations of the Prussians. These appear to have consisted, mainly, of a series of bombardments, directed either against villages entrenched and barricaded, and forming a line of strong advanced points which must be carried to ensure success, or against woods crowded with infantry, who, secure under cover of their position, could not be dislodged otherwise than by artillery fire, and even successfully defied the superior fire of the Prussian needle-gun. The results are evidences both of the effectiveness of the fire, on this occasion, and of the nature of the projectile employed. In rapid succession, the villages burst into flame, and by their conflagration assisted the enemy's shell in the expulsion of the defenders, and, that the recesses of the woods were successfully searched, was but too faithfully shewn by the groups of dead, that lay to mark the spots where the shells exploded. Notwithstanding that this nature of operation is but a reproduction of the more or less common incidents of former wars, we cannot but observe its prevalence during the battle of Königgrätz, and are led to enquire whether the case is exceptional, or may be taken as an exponent of what is in future to be expected. Making due allowance for the varieties of country, in which campaigns may be conducted, this battle may possibly be taken as a type of battles yet unfought, so far as regards the tendency of the commander of an army acting on the defensive to create obstacles, and place his troops under cover, avoiding all unnecessary display in the formation of his line of battle. The class of operations considered above, are the direct results of this tendency, and their frequency will depend upon the extent to which it may prevail.

The causes which increase the value of cover, namely, the increased precision and destructiveness of artillery and small arms, operate equally for both parties engaged in war, and accordingly, the tendency in question is manifested on the side of the attack, by the eagerness with which every fold and hollow of ground is taken advantage of, for the concealment and security of tactical movements. The dispositions and combinations of troops preceding the assault, are arranged and matured as far as possible out of sight, until the moment of attack arrives, when the columns, issuing from their shelter, move with the greatest rapidity across the intervening open space, to close with the enemy.

Regarding the Austro-Prussian campaign as a whole, it has by some been considered, that the direct results of the artillery operations were not commensurate with the force of ordnance employed, and comparisons have in consequence been made, between the efficiency of rifled and smooth-bored guns, not unfavourable to the latter. This may have arisen from imperfect training, or inferior *matériel*, or from both causes combined, or lastly, it is not impossible, that the standard of excellence for rifled ordnance, which has been established on the practice ground, will continue to cause disappointment on service, from the difficulty of attaining it under the circumstances of actual warfare.

In the service of the Prussian and Austrian guns in the battle of Königgrätz, there is one feature however, worthy of notice, common to both

armies, namely the high degree of rapidity with which the fire was delivered. Without this rapidity on the part of the Prussians, the Austrian shell, striking and bursting among their batteries as they came successively into action, disabling carriages, and dismounting guns, might have crushed the attack, and doubtless, the rapid and well sustained fire from the entrenched batteries, contributed largely towards arresting the progress of the Prussian line of battle.

It will readily be seen that the introduction of breech-loading rifled small arms will tend to the same practical result, namely to make cover of every description of incalculable value whenever attainable, whether in the pitched battle on a chosen position, in the accidental combat, or in the close fighting of the mountain defile or village street. The late campaign in Bohemia has taught practically, what no doubt was before theoretically known, that the great superiority of the breech-loading small arm, lies in its rapidity of shooting, and that cover alone enables the muzzle-loader to stand before its continuous fire. This is abundantly exemplified by the result of every combat, in which the Austrian and Prussian infantry were opposed to each other with an equal front and without cover, in the streets of the Bohemian towns. Each day told the same tale of a sanguinary fight, and a town lost to Austria. On the other hand, the Austrians, ensconced in the woods of Sadowa, successfully stayed the tide of the Prussian advance, until the fatally decisive moment of the day arrived. Then again, the needle-gun had a fair field, and insured to a brilliant manœuvre the success it deserved. The Prussian column forcing itself wedge-like into the right of the position, was enabled to make good its ground, and develop its front, from the impotence of the Austrian battalions to subdue the breech-loaders by their feeble fire, or close with an enemy thus armed, in the open field. Had the Austrians, now twice the victims to exemplify the danger of delay in the adaptation of science to war, been similarly armed, although victory might have differently inclined, the importance of cover would not have been diminished.

When the equilibrium of armies, which has been so rudely disturbed by the Prussian needle-gun, shall have been restored, by the general adoption of the breech-loading principle in small arms, the acquisition of cover will be of increased value, from the deadly nature of these weapons at close quarters. Where numbers are equally balanced, its possession may often confer an overwhelming advantage, and in the case of a numerical inferiority, it may more than ever be relied upon to restore equality.

If the foregoing considerations and deductions are justifiable, it will appear, that the common effect of the general use of rifled arms of great precision and rapidity of fire, will be to make the acquisition and creation of cover, both natural and artificial, one of the first considerations in campaigning. This may be carried to such an extent, that the *ordinary* work for the attacking artillery may be to engage batteries entrenched; to dislodge infantry posted under cover; to overthrow obstacles; to demolish the defences of villages and other posts, more or less fortified; and to clear woods and thickets; while the *ordinary* work of the artillery acting on the defensive may be to receive and keep down the fire of batteries projecting common shell with great rapidity; to check the advance of troops moving rapidly to the attack; and to disturb the evolutions of cavalry and artillery when visible. On the other hand, the *exceptional* work for artillery in the field

may be, to cannonade formations of troops drawn up without cover and comparatively stationary. Should this be so, it is natural to expect, that the arms, which have been instrumental in scaring troops from the open ground, should now possess the power of rendering their retreats untenable. This power must moreover, for obvious reasons, be looked for principally in the artillery, and its possession will in a great measure depend upon the nature of the projectiles employed, as well as upon the character of the ordnance composing the field batteries, and the amount of skill exhibited in their service.

A brief consideration may not be out of place, of the qualifications of the projectiles supplied in our service to rifled field artillery, to meet the exigencies of the various operations enumerated above. The supply of solid shot being limited to batteries of position, there remains alone a comparison between the classes of shells employed.* Although these latter consist at present of common and *segment* shell, yet in a *general* comparison with common shell, the remarks on segment shell being equally applicable to shrapnel, from the points of resemblance in their principles of action, and the shrapnel being more distinctly representative of the class to which they both belong, it will here be treated as such. At the same time it is not intended in any way to touch upon the question of the relative merits of these projectiles as compared together. Nor is it intended to detract in the slightest, from the intrinsic merits of the shrapnel shell, which has been the means of throwing so much lustre upon the British artillery during our Peninsular and Indian campaigns, as has been sufficiently attested by the highest authorities.

It is almost needless to observe that a close relation exists between the operations of war and the projectiles they demand. The nature of the former determines the principle of action to be applied to the latter. The frequency of the one regulates the proportionate supply of the other.

The tactical operations to be looked for in a campaign, may, relatively to the question under consideration, be divided broadly into two classes; those in which obstacles have to be overcome, and those in which nothing intervenes between troops opposed to each other. The varieties of the former have been enumerated, when considering the possible ordinary work for field artillery in future. For this class, the common shell appears to be especially adapted. The principle of the shrapnel, *when used strictly as such,* renders it a comparatively feeble missile against troops covered by obstacles which must be penetrated or destroyed. On the other hand, when employed as common shell with a percussion fuze, it has proved itself to be possessed of considerable power of penetration and subsequent destructive effect, and might in this manner be often employed usefully, against troops placed within the loopholed enclosures of a post. Where however complete destruction, or conflagration is desired, or where the obstacles are stubborn in their nature, or afford cover *overhead,* recourse would reasonably be had to common shell. The bullets and fragments of the shrapnel, so galling in the open, would spend themselves in vain among the branches of a wood, or the defences of a post.

* Case-shot is excluded from consideration, its application being simple and obvious.

The second class of operations, namely those where no cover exists, would at first sight appear to demand almost exclusively the employment of shrapnel shell, on account of the wide area covered by the bullets of this projectile during their descent. It may however without prejudice be discussed, in view of the increased ranges at which artillery engages, and the high degree of precision which its fire has attained, whether in the case of troops in rapid motion and in close formations, the use of common shell might not sometimes be preferred.

It cannot but be admitted, that it is essential to the maintenance of good practice, that the effect of each round should be correctly ascertained. This at long and fluctuating ranges when firing shrapnel shell, is attended with much difficulty. In such cases it might not be ill-judged to prefer the direct impact of the common shell, since the effect can be more readily ascertained, and the range estimated with greater accuracy from the absence of error due more or less to the action of a time fuze.

As the distance between two opposing armies diminishes, or the enemy's dispositions become more extended, the advantages of shrapnel will come more decidedly into play. A shortening range brings a flattening trajectory, and an increasing velocity at the moment of bursting. These circumstances not only greatly increase the effect of a shrapnel shell bursting truly, but also largely increase the limits of error in favour of doubtful shells, while at the same time the facility of judging of the effect upon the enemy's ranks, and of the accuracy of the practice is much greater.

In order therefore to confine the matter within narrower limits, these operations where no cover exists, may be subdivided into operations of artillery against troops in motion, and those against troops drawn up in stationary formations. For the latter of these sub-classes, shrapnel shell would perhaps be exclusively preferred, unless the range were so great as to leave a velocity in the shell at bursting, of so low a degree, that no useful effect could be expected from the bullets on dispersion. For the former sub-class, the choice of the projectile which would afford the best result, may be influenced as well by the range, as by the nature of the enemy's formations, the rapidity of his motion, and the direction of his march.

For the attack of artillery, although exposed and stationary, the superiority of the shrapnel shell may not be so readily granted. The object in this case is to silence the enemy's fire, and this is more effectually done by disabling the carriages and dismounting the guns, than by thinning the detachments. The shell employed should therefore be that which is best suited for the destruction of *matériel*, and the common shell appears to be the one best adapted to that end.

It may be urged in objection to the foregoing, that the work here anticipated for field artillery in general, would be more satisfactorily performed by howitzer batteries, that is to say, by batteries of rifled pieces of increased calibre, comparatively lighter in metal, but throwing a shell of weight and capacity for bursting charge greater than those of the shell furnished to field guns. As regards the size and nature of the projectile this would undoubtedly be the case, but the conditions of howitzer fire are perhaps not so favourable. The small firing charge employed to project the shell entails a sacrifice of velocity, and consequently a heightened trajectory. These

conditions, desirable where obstacles have merely to be surmounted, are disadvantages where entrenchments, walls, and other defences, have to be burst through and demolished, and where the smashing power of shot is looked for in shell. The operations for which the howitzer class of ordnance are especially adapted will however still present themselves on service. Cases might well occur where a highly curved fire would be essential, and where the increased capacity of the howitzer's shell would confer a preponderating advantage. It is perhaps however not impossible to combine such elements in a single rifled piece for field service, as that it shall possess the qualifications of both gun and howitzer. It may indeed be a difficult matter, to distribute the maximum weight of metal admissible, so that the piece shall possess strength and length of bore sufficient for the effective employment of the charges required by a gun of long range and great accuracy, and at the same time present a calibre of such dimensions, that the shell shall be formidable from the amount of its bursting charge. This is a question for those who have practical experience to determine.

In the course of these observations it has been remarked, that the power of artillery to dislodge an entrenched enemy, will depend to some extent upon the skill with which the guns are served. Modern field-artillery practice demands a high degree of precision at long ranges, coupled with a rapid delivery. The precision of fire attained with solid shot is still attainable with common shell, while it would appear to be sacrificed to some extent in shrapnel fire, where the explosion of the shell takes place, not at the end, so to speak, of the trajectory, but at some point in it depending upon the action of a time fuze. This description of fuze therefore appears to introduce an element of uncertainty as regards precision of fire, and it is not unnatural to suppose that the preparation of the time fuze in the excitement of action tends to confusion and loss of time, in however small a degree, thus affecting the efficiency of the fire as regards rapidity.

To sum up in a few words the substance of the foregoing pages, it may be stated, that it appears to the writer probable, that one of the direct effects of the use of arms of great precision and rapidity of fire, will be to enhance the value of cover to such an extent, that the *ordinary* duty of field artillery may be to engage in operations in which serious obstacles have to be overcome, or to oppose the advance of troops taught to take advantage of every feature of ground which may afford protection, and moving with increased rapidity across the ground which lies between the extreme ranges at which artillery opens, and those ranges which come within the scope of case shot.

The conclusion to which this opinion tends, is, that the occasions requiring the use of common shell in the field, may be considerably increased, and further, that the operations may require, that this shell should be projected, not from howitzers, properly so called, but to a considerable extent from shell-guns retaining a high velocity and power of penetration.

The consideration of the maximum size of shell which would be admissible, introduces the important question of transport, and the proportionate supply which might be allowed per gun, depends upon the probable frequency, which experience or opinion might assign to the operations requiring this nature of projectile.

THE COMPARATIVE ADVANTAGES OF BREECH LOADING AND MUZZLE LOADING SYSTEMS

FOR

RIFLED FIELD ARTILLERY.

BY LIEUTENANT-COLONEL F. MILLER, R.A., VC.

"Fatis ingressus iniquis."—ÆNEID III. 17.

In the latter part of last year, the year 1866, a Committee of Artillery Officers, selected exclusively from the highest ranks in the service, was assembled under the joint authority of the Commander-in-Chief and the Secretary of State for War, to report upon certain questions relating to artillery matters.

The president was Lieut.-General Sir Richard Dacres, K.C.B. The members were twelve, comprising five Major-Generals, one Brigadier-General, four Colonels, and two Brevet Colonels. The officers holding the highest administrative appointments were included in the number.

Such an assemblage of artillery officers, all distinguished by rank, experience, and official employment, has never before, so far as I am aware, been brought together, but the subjects for their consideration included one of the highest interest and importance; they had to report whether it is desirable to perpetuate the use of the present breech-loading system in the rifled guns for field service.

It is probably generally known that their decision was given in favour of a muzzle-loading system, and as this conclusion may excite some surprise I propose to give in a concise form the principal facts and arguments which support it.

It may be advisable to guard against any misapprehension as to how far the decision implies a condemnation of the guns in present use, by stating that no want of confidence is felt in their efficiency or qualities under *ordinary conditions* of service. Their normal performance is admitted to be excellent, but there are certain difficulties about keeping them in good order, which are not sufficiently compensated by any advantages accruing from their use. The difficulties, or the consequences liable to result, are not considered by the Committee so pressing as to demand an immediate alteration in the system, but render unadvisable a persistence in it. There is no prospect, so far as

human foresight extends, of any further radical change in field artillery; rifled guns of about the present size and calibre promise to continue in use for centuries, fresh pieces will have to be manufactured as the existing ones wear out, and if the breech-loading system is disadvantageous it cannot judiciously be adhered to. The actual terms of the Committee's decision are "that the balance of advantages is in favour of muzzle-loading field guns, and that they should be manufactured hereafter."

It is doubtless a serious inconvenience and a heavy expense to alter so much of the *matériel* as is already in use. On the other hand it is unwise to continue to arm the field artillery with costly guns which require special skill and care to keep them efficient, whilst in shooting qualities they are no whit better than guns of a simpler description. The skill, trouble, and appliances are uselessly incurred when no special advantage is gained, and the fact of their being necessary implies some risk if they are not regularly bestowed. The chances of a gun being unfit for use at a special moment may be but slight, but if such a thing should occur at an important crisis the consequences might be disastrous.

As the decision only affects field guns, any of the merits or demerits possessed by breech-loading ordnance for other services may be dismissed from present consideration. The question is also practically restricted to the breech screw construction, because it is the only one introduced into our field service, and no other mode of closing the breech would be likely to prove so superior as to justify a change in that direction.

The principal source of information for the arguments and facts bearing on the point is the voluminous Blue Book, of about 650 pages, containing the report and proceedings of the Special Committee on the different guns and ammunition proposed by Sir William Armstrong and Mr Whitworth.* The committee was appointed on 1st January 1863, and their proceedings lasted till 3rd August 1865. They examined twenty-seven witnesses of experience in the manufacture or use of artillery, whose evidence, contained in 4132 questions and answers, is appended to the report. They also carried out a long and exhaustive series of trials with guns submitted by the two competitors, and the value of the stores alone, besides the other expenses of the enquiry, amounted to £33,500.

The guns consisted of 12-prs., taken as a type of field artillery, and 70-prs. selected partly because they sufficiently represented the heavier guns then in general use for siege, garrison, and naval purposes, and partly for other reasons. Three of each kind were supplied; Sir William Armstrong furnished two natures of guns, a breech-loader and a muzzle-loader, in each calibre: he did so for the express purpose of enabling a comparison to be made between the merits of the two systems; considering as he stated to the Committee that it was for artillerists to decide which was the proper system for the service.† Had it not been for this duplicate provision it would have been difficult or impossible to eliminate from the results, given

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* It is to this book that the references in the foot notes apply when not otherwise specified.

† Evidence, Quests. 147, 156. When however the lead coated projectile, which entails a breech-loading system, was first tried there was no other which could give results comparable with it. (Sir W. Armstrong's evidence; Ques. 146).

by the Armstrong breech-loader and the Whitworth muzzle-loader, the differences due to causes independent of the peculiarities involved in the manner of loading.

The Armstrong 12-prs. were of 3 inches calibre and threw projectiles of the following weights: solid shot 11·56 lbs., segment shell 11·5 lbs., common shell 11·19 lbs. The breech-loaders were polygrooved in the usual mode, and the muzzle-loaders were on the "shunt" principle. Both had a twist of 1 turn in 35 calibres. The muzzle-loader was shorter in the bore, 67·74 instead of 73·5 inches, but had more metal than the breech-loader. Its weight was 8·93 cwt. instead of 8·5 cwt: its charge also was 4 oz. more, $1\frac{3}{4}$ instead of $1\frac{1}{2}$ lb. of powder. The bursting charge of the common shell was $1\frac{1}{2}$ oz. less, being only $9\frac{1}{2}$ oz.; that of the breech-loading common shell being 11 oz.*

The practical tests to which the guns and ammunition were submitted may be classified as follows, and will be noticed in the order by which they are arranged.

A. *Shooting qualities;* as to (1) range; (2) initial velocity and retardation; (3) accuracy.

B. *Practical effect in the field* against (4) earthen field works; (5) walls; (6) stockades; (7) field artillery; (8) targets representing bodies of troops.

C. *Service of the guns;* (9) ease of working; (10) rates of firing; (11) extent of recoil; (12) boat service.

D. *Hard usage and rough work;* (13) endurance; (14) strength; (15) power of withstanding effect of a shell bursting inside the bore, and (16) of a shot striking the outside; (17) capability of being brought into use after being upset.

E. *Durability of the ammunition,* (18) under travelling; and (19) under exposure to wet.

The details of all these trials are contained in the Appendix to the Blue Book, and the results are summed up in the Committee's report. The extracts in this paper will be given as briefly as possible, and be confined to a comparison between the Armstrong field guns; the references that may be made to results with the Whitworth gun being introduced only when they seem to throw additional light on the qualities of muzzle-loading, as opposed to breech-loading pieces, or have a separate interest sufficient to justify a departure from the usual course.

(1) *Range.*

The ranges were tested with shot and with segment shell fired at various elevations from 0° up to 33°, with the results shown in the following table:—

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* Report, p. 15. N.B.—In the Blue Book the pages of the report are in Roman numerals, and the rest are in the usual figures.

*Ranges with Solid Shot and Segment Shell.**

Elevation.	No. of rounds.†	B.L. mean range.	B.L. mean error.	M.L. mean range.	M.L. mean error.	Remarks.
	solid shot	yds.	yds.	yds.	yds.	
0	18	466	10·8	514	19·0	Range of M.L. 8 per cent above B.L. = 6′ elevation.‡
1	12	846	11·8	931	10·7	" M.L. 9 " " 13′ "
2	18	1186	19·7	1265	11·7	
3	18	1492	18·6	1598	12·9	" M.L. 7 " " 21′ "
4	18	1770	17·9	1923	15·9	
5	18	2115	28·1	2230	23·1	M.L. 5 per cent above; = 22′ elevation.
6	18	2384	27·9	2564	20·6	
7	18	2684	27·2	2855	18·4	M.L. 6 per cent above; = 35′ elevation.
8	18	2975	21·4	3099	20·8	
9	18	3224	23·0	3327	27·1	
10	18	3460	19·0	3524	32·7	M.L. 2 per cent above; = 16′ elevation.
15	9	4710	32·0	4719	45·1	Both guns equal in range.
25	9	5988	54·9	5981	49·5	
33°	9	6788	75·9	6774	68·	
						Sums of the ratios of mean errors in ranges. B.L. 19·3 / M.L. 18·8
5°	20 segment shell.	1848	25·9	1925	18·7	After the guns had fired 2800 rounds.
0	16	505	16·0	568	12·7	Range of M.L. 12 per cent above B.L.; = 12′ elevation.
3	18	1445	15·3	1607	26·5	11 " " 25′ "
5	17	2080	31·2	2277	31·5	8 " " 39′ "
7	17	2644	34·9	2798	57·8	5 " " 42′ "
10	15	3306	87·0	3600	71·1	8 " " 1° 19′ "
						Sums of the ratios of mean errors in ranges. B.L. 5·92 / M.L. 6·82

The comparisons in the column of remarks are deduced by the Committee from the general results of the practice. It appears from them that the muzzle-loader gave a rather longer range than the breech-loader both with solid shot and segment shell. In uniformity of range it was also slightly superior with solid shot, but inferior with segment shell. On the whole there was no important difference between the two guns.

The trial at 5° elevation after each of the guns had fired 2800 rounds was an interesting feature of the experiment. The falling off in mean range with the breech-loader was from 2115 yards to 1848 yards equivalent to 43′ of elevation. With the muzzle-loader the range fell from 2230 yards to 1925 yards, or 14 per cent, equivalent to 1° of elevation.

This loss of range was apparently due to the escape of gas consequent on the enlargement of the bores during the course of the experiment. The bore of the breech-loader was enlarged from ·029 to ·036 inch in front of the seat of the shot. The bore of the muzzle-loader was enlarged only to the extent of ·003 inch, but there was also very much scoring all round and

* Report, p. 18.

† After elimination of a per centage of the most unfavourable results.

‡ This is the increase of elevation which the breech-loader would require to obtain the same range.

in the grooves, whereas the bore of the breech-loader was uninjured in that respect.*

The deterioration of the bore, being more closely connected with the question of endurance, will be further noticed in the 14th division of the trials. The scoring in the muzzle-loader would not it appears, have been near so great if wads had been used throughout, as they were in the latter part of the firing.

(2) *Initial Velocity and Retardation.*

The initial velocity was calculated from the observations made with Navez' apparatus in the usual manner. The retardation or loss of velocity was ascertained by using two of Navez' instruments together, and observing the velocities of the same shot at two points of the trajectory; one near the muzzle of the gun, and the other at 800 yards further off. The difference between the two observations showed how much velocity was lost in passing through the intermediate distance.

The following table shows the results of five good observations with each nature of projectile:—

Projectile.	Initial velocity.		Loss of velocity.		Remarks.
	B.L.	M.L.	B.L.	M.L.	
Solid shot	1246	1356	190	247	
Segment shell	1248	1356	189	247	
Common shell	1238	1358	184	238	
do	1319	...	...	...	$1\frac{3}{4}$ lb. charge.

It will be observed that the initial velocity of the muzzle-loader is the greater of the two. The retardation is also greater, but does not make up for the difference until the range becomes very long.

The second velocity shown with common shell from the breech-loader was obtained by raising the firing charge from $1\frac{1}{2}$ to $1\frac{3}{4}$ lb., the same amount as was used for the muzzle-loading gun.

(3) *Accuracy.*

At ranges not exceeding 900 yards the hits on targets 9 feet square were found to give a fair record of the practice, but at longer ranges, when the targets were occasionally missed, a different mode of proceeding had to be adopted in order that the proper value might be assigned to shots which failed to hit the object aimed at.

The plan followed by the Committee was to deduce the accuracy, by means of calculation, from the shots fired to ascertain the ranges. The line

* Report, p. 19.

of direction having been fixed, the elevation was given by a spirit-level, and the point where each shot struck the sands was transferred to an imaginary vertical plane by a calculation based on the angle of descent. On this plane the mean radial distance could be obtained, and taken as a means of comparison by the ordinary process.

To get a still more convenient comparison for accuracy a figure of merit was adopted in which unity was assigned to the best shooting gun at each range, and to the other guns a figure proportionate to the mean radial distances of their shots from the centres of their groups. The results thus obtained are shown in the accompanying table.*

Table of Accuracy.

Elevation.	No. of rounds.	B.L.			M.L.			Remarks.
		mean range.	radial distance.	figure of merit.	mean range.	radial distance.	figure of merit.	
	Sol. shot.							
0	6	503	14	1·3	519	11	1·0	Up to 900 yds., 41 rounds; M.L. gun 48 per cent superior.
0	18	466	21	3·0	514	17	2·4	
1	5	867	29	1·2	905	24	1·0	
1	12	846	40	2·5	931	16	1·0	
2	18	1186	54	1·6	1265	39	1·2	From 900 to 2000 yds., 54 rounds, the M.L. gun 41 per cent superior.
3	18	1492	60	1·3	1598	63	1·3	
4	18	1770	70	...	1923	65	1·1	
5	18	2115	131	2·2	2230	114	1·1	
6	18	2384	162	1·6	2564	118	1·2	From 2000 to 3000 yds., 54 rounds; M.L. gun 25 per cent superior.
7	18	2684	165	1·7	2855	140	...	
8	18	2975	166	1·1	3099	185	1·2	
9	18	3224	208	1·4	3327	251	1·8	
10	18	3460	191	...	3524	363	2·3	
5	20	1848	112	...	1925	95	...	
	Segment shell.							
0	16	505	29	...	568	15	...	Up to 2000 yds., 51 rounds; B.L. gun 5 per cent superior.
3	18	1445	54	...	1607	110		
5	17	2080	147	...	2277	165		
7	17	2644	264	...	2798	376		
10	15	3306	821	...	3600	608		
	Common shell.							
0	4	505	10	1·7	533	11	1·8	Up to 900 yds., both guns equal.
1	"	874	17	1·1	913	15	1·0	
2	"	1188	37	1·6	1301	23	1·0	From 900 to 2000 yds., M.L. gun 56 per cent superior.
3	"	1487	46	1·2	1603	53	1·4	
4	"	1740	100	...	1952	29	1·0	
5	"	2042	73	2·5	2216	72	1·0	From 2000 to 3300 yds., both guns equal.
6	"	2320	84	1·1	2587	94	1·0	
7	"	2633	102	1·1	2888	67		
8	"	2874	110	1·0	3066	382	3·4	
9	"	3128	159	...	3349	90	1·0	
10	"	3302	295	3·2	3523	270	1·0	

With solid shot the superiority of the muzzle-loader is very manifest. With segment shell the breech-loader shows a slight advantage. With

* Report, pp. 22, 23, 24. The results given in the report in separate tables are here united in one.

common shell there is an extraordinary discrepancy between the results up to 900 yards and again above 2000 yards range, and those obtained at the intervening distances. This is not explained, but the Committee remark that the number of rounds fired at each elevation with these projectiles was so small that the results are less than usual to be depended upon. They did not extend the trials because 12-pr. common shells would be very rarely used on actual service.*

Division B. *Effect in the Field.*†

In this course of trials it was frequently impossible to make an exact comparison between the different guns, or between the different kinds of projectiles; they contribute therefore but little towards a comparison of the two constructions, but they have a general interest sufficient to claim a short notice.

(4) *Earthen Field Works.*

The field work consisted of an ordinary earthen parapet with an abatis in front. It was pierced with embrasures, and each embrasure was furnished with a gun, mounted on a garrison carriage, round which were placed wooden figures to represent the gun detachment. Behind every gun there was also a target, 18 feet wide by 9 feet high, to catch the splinters and segments of the projectiles.

The abatis was rendered practicable for assault by 15 rounds at 600 yards. The projectiles were five of each kind, but the common shell caused little damage.

At the embrasures 45 rounds per gun were fired, viz. 10 at 1300 yards, 20 at 900, and 15 at 700 yards. The projectiles were 15 of each kind, but the common shell were not used at the longest range, a double number being fired at 900 yards instead.

The effect inside the work was:—

Breech-loader, 13 figures struck; 136 holes through the target; 26 fragments lodged in the target; gun and carriage damaged.

Muzzle-loader, 4 figures struck; 35 holes through the target; 14 fragments lodged; gun struck.

The embrasures were subsequently fitted with mantelets made of four plies of 4 inch rope, with a target, of the same dimensions as before stated, 6 yards behind each mantelet.

Segment and shrapnel shells (the latter from the Whitworth gun) with percussion fuzes, were then fired at them, first, through a wooden screen placed in front of the embrasure, and secondly, direct against the mantelet. The object of introducing the screen was to cause the bursting of the shell at a definite point, and thus to get the effect which would be obtained with a time fuze acting at that moment. The range was 400 yards.

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* Report, p. 25. † Ibid. p. 34.

The results for the time fuze arrangement, three rounds, were:—

Segment shell, breech-loader, 1 hole through mantelet, 0 hits on target.
" muzzle-loader, 1 hole; 4 hits.
Shrapnel shell, Whitworth, 14 holes; 37 hits.

With the percussion fuze the shells were burst by the action of striking the mantelet, and made the following hits on the target beyond: only two rounds were fired:—

Segment shell, B.L., 170 hits.
" M.L., 200 "
Shrapnel shell, W., 216 "

This shows that such mantelets are not sufficient protection against any 12-pr. shells with either kind of fuze. It also shows a decided superiority of penetrating power in the round bullets of shrapnel shell over the angular bits of segment shells.*

(5) *Walls.*

Three walls, 18 ft. long, 8 ft. high, 28 inches thick, built of the best bricks laid in cement, and offering a resistance equivalent to what large houses or churches would present in field operations, were cannonaded from 1150 yards distance with shot and shell of both kinds.

The walls were considerably damaged by only 15 rounds from each gun, and targets placed 6 ft. in rear bore unmistakable evidence that at this range such walls would afford but little defence. No exact opinion could be formed as to which gun would be the most effective for similar purposes.

(6) *Stockades.*

These were formed of elm logs, 14 inches thick, placed side by side and sunk 4 feet in the ground. Their length and height were 18 feet and 9 feet respectively, the same as the walls, and targets were again placed behind to show the effects produced in rear. Ten common and ten segment shells were fired at 800 yards range.

It appeared that the nature of the material would save such a defence from being easily breached by guns of small calibre, but that troops behind would have very inadequate protection against the effect of shells burst by percussion fuzes in passing through it.

(7) *Field Artillery.*

In this trial a wooden screen was again used to produce, with a percussion fuze, the effect of a time fuze acting at 25 yards in front of a field gun, arranged as in action, with dummy figures round it and a limber behind. The range was 1000 yards, and 9 rounds of segment shell were fired.

The B.L. gun struck 29 figures and made 16 hits on the carriage and limber. The M.L. gun struck 31 figures and made 53 other hits. The results seemed to depend very much on the chance of the projectiles striking in favourable positions. I would remark that the general average of figures struck is more than 3 per round, so that with steady practice, in positions

* Report, p. 34.

where the exact range was known, an enemy's battery ought to be soon disabled. Smooth-bored guns could not long oppose such a fire.

(8) *Targets to represent bodies of troops.*

A long course of experiments was made to test the effects of segment and shrapnel shells in this manner. The targets, 9 feet high and 54 feet long, were placed in one or more rows according as they represented troops in line or in column. The shells were fired at ranges of 600, 800, and 1300 yards, arrangements being made to burst them in positions as nearly similar to one another as possible, so as to eliminate the irregularity arising from the action of the fuze, and other casual sources of difference. They were also tried as substitutes for case shot at ranges varying from 50 up to 450 yards.

The exact details are too complicated to be inserted at length; the general conclusions of the Committee are as follow:—

In firing against troops in line, if the shells explode only 10 yards in front the fragments are concentrated more than is desirable. If they explode at 25 yards in front the distribution is better, and was found about equal from each kind of gun. When burst at 50 and 100 yards the shrapnel shell had a marked superiority, owing to the bullets maintaining their velocity and direction better than the angular segments.

In firing at columns of troops the shrapnel is much more formidable than the segment shell, owing also to the qualities just mentioned.* It was found however far inferior to the segment shell, both as to the distribution of fragments and the number of hits when they were burst by grazing on the sands, under the ordinary application of the percussion fuze.

The Committee observe, relative to this description of fire, that all the shells proved to have a comparatively small effect when burst by a graze 50 or 60 yards in front of troops; from which it follows that a good time fuze is of much importance, They recommend that it should always be used in combination with the percussion fuze.

On reviewing the whole of the practice with segment and shrapnel shell, they are of opinion that the latter is the more formidable of the two.†

The effects produced at short ranges by the shells used as a substitute for case shot were not very great, and as the time necessary to adjust the fuze would render them of comparatively little value in checking a rapid advance, the Committee think it absolutely necessary for field guns to be supplied with common case.

They tried accordingly two kinds of case shot; one proposed by Lieut. Reeves, R.A. for Sir William Armstrong's guns, and one proposed by Mr Whitworth for his own guns. They report that the latter possesses a marked superiority, and that it is an invention of great value to the service.‡

It is evident that in firing against such irregular and scattered marks as field guns, dummy detachments, and other ordinary objects of artillery practice in the field, the number of hits must be a good deal dependent on

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* Report, p. 37. † Ibid. p. 38.

‡ Report, p. 36. No description is given of this case shot in the blue book, or, if it is, I have been unable to find it.

chance, but the foregoing experiments are interesting as examples of actual practice carefully conducted. One essential point of difference between the muzzle and the breech-loading systems, viz. the necessity of employing in the latter a time fuze ignited by mechanical action, was not brought under trial, because one fuze was used for both the Armstrong guns, and a time fuze also on that principle of ignition, (designed by Colonel Boxer) was used for the Whitworth gun. The times of burning were tested by firing 20 (in all), at 3°, 4°, 5°, and 6° elevation, and noting carefully by stop watches the time between the discharge of the gun and the explosion of the shell.* The results were:—

B.L. Armstrong;	mean difference	·36 seconds;	5 blind.
M.L. "	"	·10 "	0 "
Whitworth	"	·24 "	2 "

(9) *Ease of working.*†

The ease of working the guns was tested by repeated experiments of long and rapid firing, the guns being placed in battery side by side, and every endeavour being made to put them on a perfect equality in all respects. With the breech-loader three vent-pieces were used, each being changed when it became hot. Oil and water were applied to the breech screw in two out of the three days firing; lubrication for the bore was found to be indispensable for any continuous use. The results may be judged by the rates of firing attained.

(10) *Rate of Firing.*‡

The rate of firing was tried, in all, five times: three times with the ordinary ammunition and the ordinary service; once with the omission of lubrication, and once with the breech-loader only, to ascertain what rapidity was practicable with a carefully selected gun detachment trained to serve it in a manner different from that laid down in the drill book.

By this alteration one gunner worked the vent piece whilst another primed and fired, instead of both duties being performed by the same man, and an extraordinary increase of rapidity was thereby attained. One set of 50 rounds was fired in 6 min. 59 secs.; another 50 in 6 min. 39 secs.; averaging 1 round in 8·18 secs. or upwards of 7 rounds per minute.

With the usual drill and the proper ammunition both guns were practically equal, the results of the first three days firing were as follow, but the muzzle-loader had been under a disadvantage from the cartridges being above the right gauge on the first day, and by the platform shifting on the last day. The Whitworth was fully as rapid as the breech-loader.

	1st day 200 rounds.	2nd day 99 rounds.	3rd day 98 rounds.	Average time per round.
B.L.	80 m.	51 m. 21 sec.	35 m. 34 sec.	25·22 sec.
M.L.	81 "	57 " 39 "	37 " 14 "	26·6 "
Whitworth ...	72 "	59 " 0 "	33 " 24 "	24·84 "

4th day: lubrication omitted.

B.L.	20 rounds	in about 11 min. 33 seconds per round.
M.L.	86 "	in 28½ min. 19·5 sec. per round.
Whitworth	86 "	in 34½ min. 24·1 sec. per round.

* Report, p. 40. † Ibid. p. 25. ‡ Ibid. p. 27.

The firing from the breech-loader had to be discontinued after the 20th round without lubrication, from the lead stripping off the shot and the breech closing apparatus becoming disarranged. This trial showed that the gun would be unfit for use in the field, if, by any accident the lubricators were not at hand. The bores of the other guns were examined at the end of the firing, and were found uninjured by it.

The Committee remark that the rapid firing of seven rounds per minute obtained by exceptional arrangements from the breech-loader was a feat inconsistent with proper laying of the gun, and that it would have been attended with risk if performed in the heat of action. The utmost rate consistent with steady aim and good practice is quite attainable, they consider, with the muzzle-loader.

To this might be added the consideration whether ammunition could be supplied quick enough in the field for more rapid firing. In these experiments, where the main object was to ascertain how quickly a gun of a certain construction could be loaded and fired, apart from all other considerations, the supply of ammunition was arranged so that no delay should be caused on that account. In the ordinary operations of field service it is held dangerous to have the provision of cartridges close to the piece when in action. The limber takes a position in which the boxes are 25 yds. from the muzzle of the gun; the cartridge has to be taken out of its cartouche, the shot to be lifted from its place, and each to pass through three different hands before it is put in the bore and rammed home. Whatever might be done by special arrangements, and with the same men always told off for the same duties, it may be doubted whether guns coming into action, on any chance encounter, could be supplied with more than three rounds per minute, and the Armstrong muzzle-loader showed itself capable of this on the last day's trials. Former data allowed two rounds per minute with approximate accuracy, and this is fairly corroborated by the rate of one round in about 25 seconds which is the general result of the whole trial.

At the same time it should not be overlooked that on occasions like the defence of an entrenched position, there might be the opportunity for making special preparation, including that of having ammunition closer than usual, and a few extra discharges against an assaulting party might be highly advantageous if the guns were capable of such a rate of firing. It must therefore be conceded that the quality is a merit, but such occasions are so rarely met with that it has little practical value.

(11) *Extent of Recoil.**

The mean recoil, as measured on the platforms when the guns were fired under like circumstances, was 66 inches for the breech-loader and 76 inches for the muzzle-loader. This is in accordance with the higher firing charge in the latter and with the higher initial velocity obtained.

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* Report, p. 27.

(12) *Boat Service.**

For boat service the guns were mounted and worked in the bows of pinnaces; they were also thrown overboard, dragged ashore, remounted on travelling carriages, moved forward a few yards, and again brought into action.

In both respects the breech-loader proved itself decidedly the quickest gun to handle. It fired one round per minute, whilst the muzzle-loader required 1½ minute, and its detachment was also less exposed. In the landing operation it had fired a shot at the end of 3½ minutes, the muzzle-loader requiring nearly 5½. The Whitworth required about the same time. The Committee consider that the difference in favour of the breech-loader is fairly due to its comparative lightness and handiness. Nevertheless the Admiralty has declared in favour of muzzle-loaders for boat service† (but made shorter than these pieces), because naval men fear that in similar operations there would be a serious risk of some separable part of the breech-screw apparatus being dropped and lost, and the gun thereby disabled.

(13) *Endurance.*‡

The durability of both the guns proved very satisfactory, for 2800 rounds with full service charges were fired from each, and they continued quite fit for service, though with some falling off in their shooting powers, as already noticed under the range experiments.

Before describing the condition of each, it should be stated that the firing from the muzzle-loader began without any lubricators being used, and it was not till 867 rounds had been completed that wads were adopted. Had they been used throughout they would have much lessened the injury suffered from the gas, for the progress of the scoring in the bore and in the grooves was considerably reduced during the rest of the practice.

The principal injuries reported on examination are as follow:—

Breech-loader.—Several fissures in the powder chamber, and considerable scoring in the slot from escape of gas round the vent-piece. The shot chamber expanded from ·002″ to ·003″; the bore in front of the shot chamber enlarged from ·029″ to ·039″, this enlargement extending for 4″ and then decreasing until it disappeared at 30″ from the bottom of the bore.

Muzzle-loader.—The scoring began at about 8″ and extended to 17″ from the bottom of the bore. In the grooves it extended about 2″ further, and was about ·2″ deep. A very slight enlargement, amounting at its maximum to only ·003″, began at 5″ and ended at 9″ from the bottom of the bore. In front of the vent there were slight fissures, and there was some wear round the edge of the vent copper.

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* Report, p. 26.

† Proceedings of the Committee on Field Artillery.

‡ Report, p. 28.

During the 2800 rounds the muzzle-loader was revented twice: the first time after 1714 rounds, the next after 524; the last vent therefore was fired 562 times with the service charge, and 60 times more with the increased charges finally used.

The breech-loader with its three vent-pieces had all the copper rings renewed twice; the first time after 867 rounds, the next after 904 rounds. The rings were refaced six times, and the vents were renewed once.*

(14) *Strength.*

These guns were finally fired with increased charges, and with air space left between the powder and the shot, to ascertain whether they would burst suddenly and violently, or give previous indications of a liability to give way. Both broke up gradually and in a manner which would have inflicted no damage to a gun detachment. The breech-loader furnished an interesting example of what the apparatus is sometimes able to endure, by the vent-piece and breech-screw remaining uninjured to the last.

The Whitworth gun stood longer, but ended by bursting violently, and without any previous indication, into eleven pieces.

(15) *Bursting of a shell in the bore.*†

Each gun had five common and five segment shells burst inside it, by boring a hole in the shell's base, and opening the end of the cartridge so as to leave a free passage for the flame to pass up to the bursting charge.

In the M.L. gun no damage was detected. In the B.L. some trifling indentations were produced by the first shell burst, but they were not increased by the subsequent explosions, nor was the accuracy of firing (as tested by target practice) affected by them.

(16) *Effect of a shot striking externally.*†

Shots from a 9-pr. Armstrong gun, at 40 yards distance, were fired so as to hit each gun twice, at an angle of 30° with the line of fire. They were slightly indented, but four rounds were afterwards fired from them without difficulty.

(17) *Capability of coming into action after being upset.*†

The pieces were thrown into a muddy ditch and left there all night, so that when taken out they were more or less covered, outside and inside, with thick mud. They were then mounted (before being cleaned) and ten rounds of solid shot fired from each with the following results, reckoning the time from the order to load:—

B. L.	1st round in	2	min.	35	sec.;	10th in	7	min. 15 sec.
M. L.	"	3	"	30	"	"	7	" 50 "
Whitworth		1	"	4	"	"	5	" 10 "

* Report, p. 30. † Report, p. 29.

The execution of this trial was spoilt by casual and unequal impediments. The breech-loader was delayed about two minutes by a mistake of one of the gunners, and the muzzle-loader suffered a considerable delay in the first round by the priming irons being mislaid. The Whitworth gun met with no check.

The Committee, allowing for these drawbacks, consider that neither gun would be brought into action more quickly than the other after being upset under corresponding circumstances.

(18, 19) *Durability of the ammunition.*

The main points of difference between breech-loading and muzzle-loading ammunition consists in two features; the means by which the projectile is made to "take the rifling," and the means by which time fuzes are ignited.

The projectiles of the former system are coated with lead, which is forced closely into the finely grooved surface of the bore by the action of the discharge; those of the latter are furnished with studs, or some other projections, adapted to the grooves but not completely filling them. The grooves and studs are few in number, and the projectile has a less diameter than the bore.

The difference in the fuzes is entailed by the above peculiarity in the projectiles, for when there is no windage the flame of the powder cannot be relied on for igniting a fuze with its surface exposed in the ordinary manner. Hence an interior arrangement is necessary, and it consists in a mechanical action on a small portion of detonating composition. The difference is highly important, as the detonating composition is so sensitive, and so liable to deteriorate by damp,* that however perfectly they may act when freshly made, there is no security for their continuing to do so. This was strongly urged in the late Field Artillery Committee, but was not made the subject of experiment by the Armstrong and Whitworth Committee, as all the time fuzes submitted to them were originally intended for close fitting projectiles.

The fuzes were submitted to a long course of travelling over moderately rough roads, which all except the Armstrong time fuze bore perfectly well. These suffered from the waterproof bags in which they were packed being, in nearly all cases, cut through. The needles in the igniting arrangement suffered very seriously from rust, but this has since been obviated by making them of brass instead of iron. In three out of thirty fuzes the priming was also partially shaken out.†

The projectiles were also submitted to the same course of travelling (200 miles), packed in field limber boxes. The lead coating was generally scored, and the studs were slightly bruised, but not enough to make them unserviceable. It appeared however that the fittings of the limber boxes were apt to get out of repair, and that when the projectiles were loose, in consequence, the lead coated ones were more liable to injury than the others.

They were further tested by ten projectiles of each nature, and of each kind, shot, shell, and segment shell, being placed in straw which was

* Report, p. 41. † Ibid.

periodically wetted with fresh and salt water during the space of six months. They were not in any way injured, and afterwards bore being fired.

One of the objections alleged against lead-coated projectiles—that the lead was apt to come off or "strip" when fired,—was not experienced in these trials, except in that part of the rapid firing when lubrication was omitted. This is due to an improved mode of attaching the lead by zinc solder; the projectiles, as now manufactured, may be fully relied on for ordinary service, though doubts are still expressed whether they will equally bear the effects of very hot climates.* The only cases in which defects had been observed in projectiles with the lead attached by zinc were attributed to faulty workmanship.†

Such are the results of actual experiments, carried out carefully and conducted with apparent fairness, so far as the efficacy of breech-loading in opposition to muzzle-loading is concerned. As the object of these extracts is to furnish a simple comparison between the two, the final conclusions drawn from each series of trials connected with field service are shown in the following abstract, the gun that evidently answered best being shown by the figure 1, and equality being denoted by the sign =.

Trial.	B. L.	M. L.	Remarks.
(1) Range ..... shot		1	Mean errors ... 19·3 and 18·8
(1) Range ..... segment shell...	1		" 5·92 " 6·82
(2) Initial velocity ..... shot		1	Mean velocities 1246 " 1356
(2) Initial velocity ..... segment shell...		1	" 1248 " 1356
(2) Initial velocity ..... shell		1	" 1238 " 1358
(2) Retardation shot	1		Retardations ... 190 " 247
(2) Retardation segment shell...	1		" 189 " 247
(2) Retardation shell	1		" 184 " 238
(3) Accuracy ..... shot		1	See Table, p. 315.
(3) Accuracy ..... segment shell...	1		
(3) Accuracy ..... shell		1	
(4–8) Effect in the field	=	=	
(9, 10) Ease of working and rate of firing	=	=	Under ordinary circumstances.
(9, 10) Ease of working and rate of firing	1		By special arrangements.
(9, 10) Ease of working and rate of firing		1	Without lubrication.
(13–17) Hard usage, &c.	=	=	
(18, 19) Durability of ammunition ...		1	

Considering how different the two kinds of guns are, it is surprising that their performances should be so nearly on a par. Whatever objections may be taken to particular points of the trials the general result can hardly be disputed, and I would state it in the following terms: "that no superiority of practical value for general purposes can be attributed to the breech-screw system for field artillery." It may fairly be urged that the muzzle-loader consumed more powder and had more weight of metal, but the difference in the first, as a question of weight to be carried, only adds 2 per cent to a complete round of ammunition, and in the other it is compensated (assuming that it is indispensable)† by the absence of spare parts and cumbrous sets of tools with which breech-loaders have to be provided.

* Report, p. 39. † Evidence, Questions 2758, 2794.

‡ They were intended to be of the same weight. Report, p. 15, and Evidence, Question 157.

As a question of money the expense of the extra metal in the muzzle-loader is far below that of the machinery in the breech-loader, without reckoning the contingent cost of keeping the gun in working order. If under this head were included, as fairly ought to be, the daily pay of such artificers as might be dispensed with if a less delicate gun were in use, and the expense of providing supplies of tools and appurtenances to distant stations at home and abroad, we should have an approximation to what the maintenance of breech-loading guns amounts to. But to this would have to be added the extra expense of lead-coated projectiles, mechanically-ignited time fuzes, and special lubricators, before we could obtain the total cost of keeping up the system.

How far the saving of this difference would go towards the cost of adopting a muzzle-loading system is a matter for calculation. The Armstrong and Whitworth Committee reported, with reference to the primary manufacture of the guns alone, that the difference was so unimportant compared with the interests at stake in having the most efficient, that the question of cost ought not to influence the selection. Under the present circumstances we are exposed annually to the greater expense without the satisfaction of possessing a more efficient description of ordnance.

The Committee delivered their opinion in the following terms:—"That the breech-loading gun is far inferior as regards simplicity of construction to either of the M.L. guns, and cannot be compared to them in this important respect in efficiency for active service."* And again: "that both Sir W. Armstrong's and Mr Whitworth's muzzle-loading systems, including guns and ammunition, are on the whole very far superior to Sir W. Armstrong's breech-loading system for the service of artillery in the field."†

Major-General Taylor, the present Inspector-General of Artillery, put on record a dissent from the opinion thus strongly worded, but he admitted that the "balance of advantages" lay with the muzzle-loaders, and only claimed the recognition of certain points of superiority in the breech-loader.‡ Two other members expressed dissent from the general report adopted by the majority, but their objections were directed to other points, and did not impugn the above decision.

The chief advantages hitherto claimed for breech-loaders as field artillery guns (including those specified by General Taylor), may be briefly stated in general terms as follow:—

(1) Superior accuracy and rapidity of fire.

(2) Freedom from danger in loading, especially on field days and when used for saluting.

(3) Facility for being rendered useless to an enemy by carrying off the vent-piece.

(4) Facility for renewing the vent, which in any gun is the part which first deteriorates by use.

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* Report p. 32. † Ibid. p. 43. ‡ Ibid. p. 45.

(5) Convenience for removing any obstruction from the bore, and of ascertaining its interior condition by being able to look through from end to end.

(6) Convenience of being able to move the guns ready loaded if special circumstances render it desirable to do so.

(7) Convenience for firing at angles of considerable depression.

On the other hand the following disadvantages are alleged :—

First, as to the gun and its service.

(1) The breech-closing apparatus is liable to get unfit for use in various ways, such as: by the fracture of the vent-piece; by the breech screw becoming jammed (which may be caused by rust, by grit, by an accidental blow on the screw-threads); or by the copper facings at the junction of the vent-piece and powder-chamber losing the evenness of surface necessary for preventing the escape of gas.

(2) In the excitement of action, or by careless service, the gun may be fired when the breech-screw is not fully screwed up, in which case the vent-piece may be blown out, and at any rate the result of the shot spoilt.

(3) The number of separable parts, and the delicacy of adjustment they require for effective use, entail the occasional employment of skilled artificers, and an unremitting care on the part of the gunners, which, in the vicissitudes of a campaign, might not always be forthcoming.

(4) Some of the parts essential to the gun's working, such as the lever handle of the screw, and the breech-screw itself when the vent-piece is withdrawn for loading, project in a manner which renders the gun in some degree more likely to be hit and disabled in action.

Secondly, as to the ammunition.

(5) The detonating composition which is necessarily used in the time fuzes is liable to deteriorate, and the fuzes, if not spoilt are made uncertain in their action.

(6) The mode of action of the time fuzes is so difficult to understand and to apply, that many of the gunners are unable to thoroughly acquire it.

(7) The lead coating of the projectiles is liable to strip when the gun is fired if the original fixing is not in perfectly good order, or if there is no lubrication used; and if any saline liquid finds its way between the lead and the iron, a deleterious voltaic action is excited.

(8) The lead coating is easily injured by travelling, if loosely packed, and by being accidentally struck or dropped. If it loses its form by bulging at the base, or by getting deeply scratched, it will not enter the gun until its irregularity of form and surface are removed.

(9) If the lubricators should happen to be wanting the gun would be incapable of any continued firing.

Lastly (10). That the store department of an army in the field would be complicated and hampered to a most serious degree by the provision of all the separate articles essential to the gun, and by keeping up the necessary reserves of them.

The category of advantages and disadvantages, imaginary or real, might be extended to any length according to the ingenuity of the advocate for either system. Refutations with which they might be encountered would perhaps suggest themselves in equal number to a skilful disputant; those that have been adduced here were selected as seeming to be the only ones of much practical value, and they are open to the following comments.

Review of the advantages claimed for breech-loaders.

(1) The superior accuracy has not made itself apparent in the special trials instituted for the express purpose of testing it, and the extra rapidity is only applicable to cases of the very rarest occurrence; the muzzle-loaders are equally capable of any rate consistent with careful practice and ordinary circumstances.

(2) The danger in loading, for firing at drill and salutes, is undoubtedly reduced to a very minimum by breech-loading. Unhappily it is not altogether removed, for an accident occurred last year (6th July, 1866), in firing a salute on board H.M. Ship "Valorous." The gun in use was a 40-pr. The man who inserted the cartridge had part of his hand blown off, and another was so injured that he died shortly afterwards.* I have heard that another accident of the same nature occurred with a 12-pr. gun at Sheerness. When projectiles are used there is no possibility of injury to the gun from the shot not being rammed home, close up to the charge; but a very slight injury to the projectile itself will prevent its being loaded at all.

(3) There are occasionally cases, in course of field engagements, in which guns may be deliberately left exposed to the chance of capture, in order that their fire may continue to be delivered up to the last moment. The admirable conduct of our artillery at Waterloo may be cited as an eminent example of such a practice.† The guns were frequently left outside the infantry squares after being steadily served up to the latest possible moment, at times when the charges of French cavalry obliged the gunners to take temporary shelter behind the wall of bayonets. As soon as the cavalry withdrew, the fire was resumed. For similar occasions the power of removing the vent-piece may be conceded to be a useful property.

But if guns fall into the enemy's hands by an unexpected and sudden rush, I have little faith in the carrying out of drill instructions for rendering a gun unserviceable, and I should attach, everything considered, small value

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* Records of Ordnance Select Committee.

† Cust, Annals, &c. It is introduced by Erckmann-Chatrian in "Waterloo," as one of the characteristic features of the battle.

to any special facility for doing it. It would be interesting to know how often the spring spikes, issued for a similar purpose with smooth-bored guns, have been applied when a sudden emergency arose. It may also be held a moot point whether a gun captured in the field (especially now that every rifled system requires ammunition expressly adapted to it), is ever of practical use to its captors. The enemy's artillery can do better service by confining their attention to their own *matériel*, and other troops want the necessary knowledge for handling it. It is much more reasonable to assume that a captured piece will be guarded and sent to the rear as a trophy at the first opportunity. Little deduction would be made from its value in that respect by the vent-piece being saved.

It may likewise be added that the means of detaching the vent-pieces makes them equally liable to be lost, or removed by treachery, as to be withdrawn for the service specified.

(4) As a partial set off against the facility of replacing a worn out vent by changing the vent-piece, there is the necessity of occasionally refacing the copper rings on the vent-piece and powder chamber, and of replacing them after a time with new ones. If the trials of the Committee may be taken as a guide, a breech-loader with three vent-pieces would require the copper rings to be renewed as often as a muzzle-loader would require to be revented, and it would in addition need refacing three times.* The vent itself would at some time also have to be renewed.

The other advantages may be admitted to be convenient on special occasions, but certainly do not fall within the ordinary requirements or application of field artillery. Moreover with muzzle-loading guns arrangements could be made for arriving at the same objects, though doubtless in a less quick and easy manner.

Review of the disadvantages.

Although there may be much difference of opinion as to how much weight should be attached to the disadvantages previously recapitulated, most of them are so self-evident that they need not be again noticed. A few of them may be disputed as matters of fact, from not having fallen within everybody's experience, but none have been inserted for which good authority could not be quoted.

It may not for instance be generally known how numerous the cases of fractured vent-pieces are. In 1864 there were 45 thus spoilt; the number has been much less in the last two years, but the inconvenience has hitherto resisted all attempts to completely remedy it.†

The blowing out of the vent-pieces has, apparently, been prevented by an alteration of the pattern. On one occasion a gun was purposely fired with the breech screw only partially screwed up, but the vent-piece was not thrown out.‡ It is stated that no accidents have occurred with the last pattern introduced.

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* Report, p. 30.

† Records of Ordnance Select Committee; the number refers to 12-prs. only.

‡ Proceedings of Field Artillery Committee.

The main point is the possibility of the breech-loader being unable to fire on any occasion from its machinery being injured, from proper care not being bestowed upon it, or from such chance causes as may fairly be expected to arise in the course of a campaign. That such an untoward event is more probable than with a muzzle-loader cannot be denied, but it is maintained by some that with fair care and intelligence on the part of the officers and men it need not excite any apprehension. It is asserted by others that the risk is too great to be prudently incurred. Experience contributes but little to the data, for neither in China nor in New Zealand did the artillery have to make the long forced marches in continued wet weather, after the men had become weakened by sickness and casualties, which would be the real trial of the question. Two cases which rest on good authority may be mentioned to show that the danger is not imaginary.

In a report by Colonel Barry, commanding a field battery in the China campaign of 1860, he states that one morning "the breech screws were nearly completely jammed with rust, and the gunners, who were already overworked, would have been severely taxed in getting the guns in working order if we had had to renew hostilities at daylight."* This seems to imply that if "we" had had no choice in the matter, but the enemy had made an unexpected attack at daylight, the guns actually would have been unfit for use. The other case occurred at Aldershot, where a gun was once disabled during a whole field day by getting some grit into the screw.†

Considering the circumstances of the time when the breech-screw system was submitted by its inventor, the dangers of a European war, the recent acquisition of a rifled field gun by the French, and the superiority which this seemed to possess over any muzzle-loading system,‡ we must confess that no course was open to the government but to receive it and to actively introduce it. That simpler constructions would eventually prove practically equal to it, could not at the moment be foreseen, and it was not a time for rejecting any advantage that could be immediately realized. Like the settlement which Æneas began on the Thracian shores, the measure promised well but the fates were against it.

One of the great recommendations to the gun was a mode of construction, the "building up" system, then peculiar to it though quite independent of the breech closing arrangement. In justice to Sir William Armstrong we should always bear in mind that to him we owe the introduction of this most valuable improvement. Its importance for manufacturing purposes is sufficiently shown by its being employed, with some modifications of detail, for the enormous pieces now, for the first time in history, successfully produced and capable of being efficiently employed. Its value in providing a perfect safeguard against the frightful accidents liable to happen with all the old siege and garrison ordnance is inestimable to artillerists, and as the guns are fully able to stand firing a couple of thousand rounds, any objections about the building up system being theoretically weak may be wholly disregarded.

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* Evidence, Question 2645.

† Proceedings of Field Artillery Committee.

‡ See Note, p. 313.

It is much to be regretted that the other anticipations of advantages have not been fulfilled; the unanimous verdicts of two Committees have declared the balance to incline on the opposite side, and after studying the trials and evidence recorded in the Armstrong and Whitworth blue book, the conclusion is inevitable.

Our situation now is briefly this:—

If we had to take immediate part in a European war, we should bring into the field a delicate gun requiring constant care and a great variety of stores for its sole use; we should further be liable to the risk of the gun failing us at critical moments, but we should not have the satisfaction of getting any advantage in range, accuracy, or rate of fire which would not equally be presented by a muzzle-loading system.

Note.

Since writing the above I have met with a passage in an old French work on Artillery (Surirey de St Remy, dated 1694) which is curious and interesting in connection with the "coil" construction. It shows that the advantage of using wrought-iron with the strength in a "circumferential direction," or in other words the groundwork of Sir William Armstrong's mode of construction, was perceived nearly 200 years before it was brought to a practical application. I do not mean to insinuate that Sir William was indebted to anyone else for the idea, but I believe that invention is generally in advance of the resources requisite for reducing theory to practice, and that many designs formed on perfectly sound principles fail and become forgotten in consequence. This seems to be a clear instance of it.

The passage is as follows. The parts that are most striking are printed in italics. Whether any guns of this particular construction were tried I do not find mentioned, but a few wrought-iron guns were made, and all burst at an early stage of the firing, doubtless from the difficulty of properly welding them together. Similar difficulties impeded the earlier attempts of Sir William Armstrong, but were overcome by the superior skill and resources at his command. (See Evidence, Questions 134, 2499, &c.)

"Certains Particuliers se sont mis en teste de composer des pieces de fer forgé, et ils ont dressé de magnifiques mémoires pour appuyer leur opinion et l'utilité de ces pieces. ..... Afin de contenter la curiosité du public, et de donner à Messieurs les Ingenieurs la satisfaction de le voir informé des raisons dont ils fortifient leurs propositions, je donne icy deux de leurs memoires."

Extract from the first Memoir.

"Les canons que nous proposons et qui sont de fer forgé consistent dans *plusieurs viroles de bandes de fer roulées sur un mandrin* du calibre de la piece à faire. Les viroles s'appellent Mises, lesquelles estant percées et soudées les unes aux autres, et en elles mesmes, forment le canon depuis le fond de l'ame jusqu' à la bouche, et les mises qui sont remplies dans leur milieu forment la culasse, et le bouton."

"Nous faisons les canons de mises composées de bandes de fer roulées comme un ruban, parce que *la grande force du fer forgé est dans la longeur de ses fibres*, qui, dans cette disposition resiste justement au plus grand effort de la Poudre qui se fait sur le travers du canon."—*From Memoires d'Artillerie*, 2nd Edition, Vol. I. pp. 68 to 71.

The two memoirs occupy several pages, but the rest need not be quoted.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON 6th MAY, 1867.

BRIG.-GENERAL J. H. LEFROY, IN THE CHAIR.

1. IN submitting to the General Meeting the Annual Report and Abstract of Accounts of the Royal Artillery Institution for the year 1866-7, the Committee have much satisfaction in drawing attention to the prosperity of the Institution.

The increase of Members during the year amounts to fifty. The accompanying Table gives the distribution of the increase and decrease under the several ranks.

RANK.	£	s.	d.	April, 1866.	Additions due to promotion.	New members.	Promoted, withdrawn, and deceased.	April, 1867.
EFFECTIVE LIST.								
General and Regimental Field Officers, paying annually	1	5	0	178	+12	+ 3	— 5	188
Captains	0	16	0	402	+31	+16	—21	428
Lieutenants	0	10	0	519	0	+47	—38	528
Paymasters	1	5	0	1	0	0	0	1
do	0	16	0	5	0	0	0	5
Quarter-Masters	0	10	0	9	0	0	— 1	8
Riding-Masters	0	10	0	3	0	+ 3	0	6
Surgeons-Major	1	5	0	5	+ 2	+ 1	— 1	7
Surgeons	0	16	0	4	0	0	— 3	1
Assistant-Surgeons	0	16	0	19	0	+ 6	— 2	23
Veterinary Surgeons	0	10	0	2	+ 1	0	0	3
RETIRED LIST.								
General and Regimental Field Officers	1	5	0	27	+ 2	0	— 3	26
do. do.	0	16	0	1	0	0	0	1
do. do.	0	10	0	8	0	0	0	8
do. do.	0	7	6	7	0	0	— 1	6
Captains (D. W. Pack Beresford)	5	0	0	1	0	0	0	1
do.	0	16	0	22	+ 7	0	— 4	25
do.	0	10	0	6	0	0	— 2	4
do.	0	5	0	6	0	0	0	6
Surgeons-Major	1	5	0	2	0	0	0	2
Chaplains	1	5	0	1	0	0	0	1
				1228	+55	+76	—81	1278
Honorary Members	0	10	6	37	0	+ 1	— 1	37

Much desire having been expressed by several civilians of scientific eminence to be supplied with a copy of the "Proceedings" as published, the Committee submit for the consideration of the General Meeting an addition which they are of opinion might advantageously be made to No. II. of the Rules and Regulations, and which, if adopted, will by enlarging the list of those who are now eligible to become Honorary Members, enable requests of this nature to be complied with to a limited extent.

The ever-increasing demand for the "Proceedings" from scientific and professional men, both at home and on the Continent, is satisfactory proof of the high merit of this Regimental publication.

2. The General Abstract shews the income and expenditure for the past year. It will be observed that the amount expended on Printing and Publication (£1063. 13s. 0½d.) is exceptionally large. This has been caused by the outlay on the fourth edition of the "Handbook for Field Service," and by the payment of £119 for the printing machine referred to in the last Annual Report. It thus became necessary in December to borrow £200 from Messrs Cox & Co., but it is satisfactory to find from the Dr. and Cr. account that the credit of the Institution on the 31st March, 1867, amounted to £1747. 14s. 1d. as against £1505. 0s. 1½d., the balance creditor at the last annual statement.

3. *Printing and Publication.*—The fourth edition of the "Handbook" was completed in December. 2000 copies have been disposed of to the publisher at a remunerative price, and 500 copies have also been supplied to the Government at the cost price of 2s. each. Members of the Institution can obtain copies for themselves and for non-commissioned officers of Royal Artillery at the same rate. Twenty-six pages of table matter have been stereotyped, which will greatly facilitate the publication of future editions. The large sale which the new edition has already had testifies at once to the useful nature of the book, and the Committee have used every endeavour to ensure that it should be creditable as a publication of the Institution.

The "Handbook" having made a large demand on the time of the Printing Department, the Committee thought it desirable to employ civilian labour for some of the Papers of the "Proceedings," rather than delay their publication; and partly by this means they have been enabled to issue eight numbers of the "Proceedings" since the last Annual Report. The whole cost of this arrangement has only amounted to £18, as owing to the rapidity with which the presswork can now be performed at the Institution with Main's Patent printing machine, the whole of the required copies have been worked off in the building; and it is satisfactory to be able to state that the experience of the past year, during which period the demands on the Printing establishment have been unusually heavy, has fully established the value of the machine. The following is a list of the papers issued to Members during the year, with the names of the contributors. To these gentlemen the Committee desire to offer their thanks.

General Abstract of the Income and Expenditure of the Royal Artillery Institution, from 1st April 1866, to 31st March 1867.

Expenditure.	£	s.	d.
Expenses in Transfer of Dividend owing to new Trustees ...	2	3	0
Printing and Publication — Wages	247	0	11½
Printing and Publication — Paper, £200. 2s. 6d. Type & Materials £433. 18s. 5d.	634	0	11
Printing and Publication — Wood Cuts £102. 3s., Lithography £55. 3s. 8d.	157	6	8
Printing and Publication — Jackson's Bill	25	4	6
Chemistry	9	11	0
Photography — Chemicals and Apparatus	78	15	3
Photography — Printing, Mounting, &c.	299	13	2
Drawing	88	14	10
Lectures	23	3	1
Taxidermy	15	18	3
Classes (Italian, French, and Mathematical)	27	13	6
Library, Books, &c.	145	3	1
Museum	49	17	0
Instruments	6	15	0
Carpenter, Materials £52. 1s. 8½d, Wages £22. 7s.	74	8	8½
Insurance on £5000, to 24th June, 1867	16	5	0
Furniture and Repairs	81	12	2
Subscriptions to Societies	17	7	0
Stationery	153	18	6
Postage and Parcels	71	3	9
Wages, Clerks and Orderlies	130	9	9
Incidental	55	4	1½
War Office Photographs	19	3	4
Interest on £200 advanced by Messrs Cox and Co.	2	7	5
Cash in hand, 31st March, 1867, Secretary 2 6 10; Messrs. Cox & Co. 3 10 3	5	17	1
	£ 2438	17	0½

Income.	£	s.	d.
Cash in hand, 1st April, 1866	19	6	1½
Dividend on £1200 Consols (to 5th Jan. 1867)	35	8	0
Subscriptions, to 31st March, 1867 — Annual	954	15	0
Subscriptions, to 31st March, 1867 — Entrance	76	0	0
Subscriptions, to 31st March, 1867 — Paid in Advance	8	19	0
General Printing	337	13	5
Photography — Chemicals and Apparatus	7	0	0
Photography — Printing, Mounting, &c.	400	5	5
Drawing	49	17	11
Taxidermy	24	1	3
Classes (Italian, French, and Mathematical)	11	13	0
Library, Books, &c.	61	2	0
Carpenter, Wood, &c.	31	5	9
Stationery	165	10	6
Postage and Parcels	40	4	7
War Office Photographs	15	15	1
Advanced by Messrs Cox and Co.	200	0	0
	£ 2438	17	0½

DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1867.

	£	s.	d.
Outstanding Debts, 31st March, 1867 — Printing Material	166	18	11
Outstanding Debts, 31st March, 1867 — Stationery	110	8	7
Outstanding Debts, 31st March, 1867 — Taxidermy	4	19	0
Advanced by Messrs Cox & Co.	200	0	0
Balance Creditor	1747	14	1
	£ 2230	0	7

Woolwich,
11th April, 1867.

	£	s.	d.
Balance Creditor — Consols Stock	1200	0	0
Balance Creditor — Cash in hand, 31st March, 1867	5	17	1
Approximate value of — Books and Stationery, for Sale	135	0	0
Approximate value of — Printing Paper, on Stock	60	0	0
Approximate value of — "Handbooks" do	188	15	0
Approximate value of — Chemicals (Laboratory) £20, (Photographical) £20 =	40	0	0
Amount owing by Officers and others. — Books, &c.	37	15	1
Amount owing by Officers and others. — Handbooks— Government £50, Publisher £283, Members £10 =	343	0	0
Amount owing by Officers and others. — Drawing	7	19	11
Amount owing by Officers and others. — Photography	53	19	3
Amount owing by Officers and others. — Postage	8	0	10
Amount owing by Officers and others. — Printing	31	14	4
Amount owing by Officers and others. — Stationery	51	6	7
Amount owing by Officers and others. — Taxidermy	4	15	0
Amount owing by Officers and others. — Wood	0	10	0
Amount owing by Officers and others. — Classes, Instruction	4	0	0
Amount owing for back Subscriptions	57	7	6
A. HARRISON, Captn., R.A., Secy. R.A.I., & Treasurer.	£ 2230	0	7

List of "Proceedings" printed during the year.

On the Comparison of the Accuracy of Guns in Artillery Practice, by Professor W. Pole, F.R.S., &c., &c.

Recent Experiments with Heavy Rifled Guns in Russia. (Communicated by a Member of the R.A. Institution).

Pettman's Percussion Fuzes, by Captain Vivian Dering Majendie, R.A., Assist.-Superintendent, Royal Laboratory.

Annual Report and Abstract of Proceedings of a General Meeting of the Royal Artillery Institution, held on Tuesday, May 1, 1866. Maj.-Gen. E. C. Warde, C.B. in the Chair.

The Russian Iron-clad Fleet.

Report of an experiment carried on at Shoeburyness, on the 21st June and 7th December 1865, by the Ordnance Select Committee. (Communicated by direction of the Secretary of State for War).

Method of obtaining the Picture of a Gun in the act of Firing, as proposed by Mr M'Kinlay, Proof Master.

My Journal during the Bhootan Campaign, 1864–5. By Captain F. G. E. Warren, R.A.

Description of a Chronograph adapted for measuring the varying velocity of a Body in motion through the air, and for other purposes, by Rev. F. Bashforth, B.D. Professor of Applied Mathematics to the Advanced Class of Artillery Officers. (Communicated by the Secretary R.A. Institution).

Percussion Fuze, designed for and adapted to the Form of Case used for Shells for Rifled Guns for Field Service, by Lieut.-Colonel Freeth, R.A.

Report of Experiments with Navez's Electro-ballistic Apparatus, to determine, (1) the effect of Elongating the Cartridge on the Velocity of the Projectile; (2) the effect of the position of the Vent on the Velocity of the Projectile. By Captain W. H. Noble, M.A., R.A., Associate Member, Ordnance Select Committee.

The Woolwich Guns: their Projectiles, Charges, &c. By Captain Slessor, R.A., Assistant Captain Instructor, Royal Laboratory.

The present state of the Artillery Question. By Major C. H. Owen, R.A., Professor of Artillery, Royal Military Academy, Woolwich. (From the Journal of the Royal United Service Institution, Vol. IX.)

Palliser's (chilled) Shot and Shell. By Captain Vivian Dering Majendie, R.A., Assistant Superintendent, Royal Laboratory.

Remarks on Military Breech-loading Rifles, and their Ammunition. By Captain R. W. Haig, R.A.

Plan of Muzzle-pivoting Guns. By Lieut.-Colonel Shaw, R.A. (From the Journal of the Royal United Service Institution, Vol. IX.)

Boxer Ammunition for Snider Converted Rifle. By Captain C. O. Browne, R.A., Captain Instructor, Royal Laboratory.

Rough Notes on the History of Field Artillery. By Lieut. H. W. Hime, R.A.

The Intrenched Camp at Florisdorff. By Lieut. J. P. Nolan, R.A.

Extract of a Memorandum by the Committee of Artillery, on a system of harnessing with the Bricole (breast strap), of which trial has been made in the Artillery of the Imperial Guard. (Translated from the French, by Major Goodenough, R.A.).

Pettman's General Service Percussion Fuze. By Capt. Vivian Dering Majendie. R.A., Assistant Superintendent, Royal Laboratory.

Short Notes on Professional Subjects, 1867. (No. 1, page 1 to 4).

Memoir of General Sir Edward Charles Whinyates, K.C.B., K.H.

The Committee believing that no question could be of greater general interest to Members than that relating to Regimental Promotion, gladly undertook the publication of Brigadier-General Lefroy's pamphlet on this subject, and a copy was issued to all Commanding Officers and batteries at Home Stations, and a few copies were also forwarded to each of the principal Foreign Stations.

It has been decided in future to publish some "Short Notes on Professional Subjects" and to issue them with the "Proceedings," as often as the contributions will allow. It is believed that information in this form will prove acceptable to Members who are absent from head-quarters, and the Committee hope that many Officers who from want of time and other causes are unable to write papers for the "Proceedings," will contribute paragraphs for the "Short Notes."

In December, 1866, the first number was issued of "List of Service Guns and Ammunition," containing most useful information in an easily accessible shape. It is intended to publish a revised copy of the sheet in April of each year, and the List will be forwarded to all Commanding Officers and Batteries through the Deputy-Adjutant-General, Royal Artillery. Members requiring a copy for individual use can obtain one by applying to the Secretary, R.A. Institution, and on payment of postage. The Committee are indebted to Colonel S. E. Gordon, C.B. R.A., for compiling this sheet.

4. *Library*—There has been a moderate sale of War Office Photographs and Lithographs* during the past year. Small coloured plates (12″ × 9″) of Service Carriages, photo-lithographed at the Royal Carriage Department, can now be obtained by Members, price 3¼d. each.

Since the last Annual Meeting the Secretary has been elected a Member of the Meteorological Society, in order that the Library of the Institution may receive a copy of the publications of the Society. The Composition Fee of £10 has been paid in lieu of the Annual contribution of £1.

An illustrated weekly scientific journal, entitled "Engineering," is now purchased for the Reading Room.

A collection of Autographs of Eminent Men has been commenced, and contributions will be gladly received.

The following is the list of books, plans, &c. purchased or presented, and also the publications received from the Arundel Society. The thirteen volumes of Wellington Despatches presented by Lt.-Col. Chermside, R.A., are a very valuable addition to the Library, and the print of Lord Heathfield, from the same Officer, is an interesting and rare engraving of 1788, by Bartolozzi.

Stock has been taken of the books in the Library since the last Annual Meeting, and the Committee are glad to be able to report that only two deficiencies were found.

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* Royal Carriage Department Lithographs are now charged as follows:—

Large sized lithographs,	uncoloured,	10d. each
" "	coloured,	1s. 6½d. "
Small sized "	coloured,	3¼d. "

Books, &c. presented.

Proceedings of the Zoological Society of London, 1865	1	The Council, Zoological Society of London.
Annual Report of the Council of the Zoological Society of London, 1865	1	
Hart's Quarterly Army List, January, April, and July, 1866	3	The Committee, R.A. Library, Woolwich.
Army Equipment, Part 1, Cavalry	1	Secretary of State for War.
" Part 3, Sect. 1, Engineers	1	
" Part 4, Military Train	1	
" Part 5, Infantry	1	
" Part 7, Hospital Service	1	
Plate to accompany O. S. Committee's Report on Experiments against the "Hercules" target	6	
Extracts from the Reports and Proceedings of the O.S. Committee, Part 4, Vol. III., and Parts 1, 2, 3, Vol. IV.	6	
Royal Carriage Department Lithographs	1	
Royal Gun Factory Lithographs	38	
Royal Laboratory Lithographs	7	
W.O. Photographs	254	
Regulations for the supply of Military Stores to the Army in the Field	1	
Revised Map of the Quadrilateral, and of Venetian Lombardy	2	
Map of the Scene of the late Battles in Bohemia	2	
Map of Moravia	2	
Map of Neighbourhood of Vienna, Presburg, and Feldsburg	2	
Strength, Composition, and Organization of the Army of Great Britain	2	
Index to the Several Articles in Periodical Publications received in the War Office Library, Nos. 1, 2, and 3	2	
Ordnance Select Committee Report, on the Mounting and Dismounting of guns, of 12 and 22 tons	10	
Catalogue of Books in the Library of the War Department	1	
Campaign in Austria, 1866	1	
Venetia, with the Quadrilateral	2	
Report of the Ordnance Select Committee, on the Penetration of Iron Armour Plates by Steel shot	2	
Memorandum on the Prussian Army, in relation to the Campaign of 1866, by Lieut.-Colonel Reilly, C.B., R.H.A.	2	
Armstrong guns, land service	12	The Deputy-Adjutant-General, Royal Artillery.
Report of a Professional Tour of Officers of the Royal Artillery, in 1865	2	

Examination Papers used at the examination of candidates for Direct Commissions, held in April 1866	1	Council of Military Education.
Examination of candidates for admission to the Royal Military College, Sandhurst, June 1866	1	
Report on the examination for admission to the Royal Military Academy, July 1866	1	
Examination Papers used at the examinations of candidates for Direct Commissions and appointment to the Commissariat, November 1866	2	
Examination of candidates for admission to the Royal Military College, held Dec. 1866	1	
Fourth Report by the Council of Military Education on Army Schools, Libraries, and Recreation Rooms	1	
Report of the final examination held at the Staff College, December 1866	1	
Report of the examination for admission to the Royal Military Academy, held Jan. 1867	1	
Charter, Bye-laws, and list of members of the Institution of Civil Engineers	1	Institution of Civil Engineers.
Minutes of Proceedings of the Institution of Civil Engineers, Vols. XXII., XXIII., XXIV., and XXV.	4	
Catalogue of the Library of the Institution of Civil Engineers	1	
Library Catalogue of the Royal United Service Institution, 1865	1	The Council, Royal United Service Institution.
Journal of the Royal United Service Institution, 38, 39, 40, and 41, Vol. X...	4	
Smithsonian Report, 1864	1	Smithsonian Institution, Washington, U.S.
Washington Astronomical and Meteorological Observations, 1863	1	
Documents of the United States Sanitary Commission, Vols. I. and II.	2	
United States Sanitary Commission, Bulletin, 1863 to 1865	3	
Thoughts on Matter and Force, by A. Wislizenns, M.D.	1	
Report of the Secretary of War, 1865.	1	
Prussian Works on Field Artillery and Coast Batteries	2	Prussian Government.
Russian Artillery Journal	8	Colonel N. de Novitzky.
" Small Arms "	4	
" Engineers "	6	
" Military "	6	
" Handbook for Artillery Officers...	2	
German Military Books	4	Lieut. E. Baring, R.A.
Prussian Works on Artillery	17	Lieut. E. F. Chapman, R.H.A.

Report of the Council of Military Education upon the First Advanced Class of Artillery Officers	2	Director of Artillery Studies.
Examination Papers, Royal Military Academy, June and December, 1866	2	Inspector of Studies, Royal Military Academy.
Madagascar and the Malagasy, by Lieut. S. P. Oliver, R.A.	1	The Author.
Réglement sur le Service des Bouches a feu Rayées	1	Lieut. H. W. L. Hime, R.A.
Artillerie, Aide Mémoire de Campagne	1	Lieut. H. W. L. Hime, R.A.
Lecture on War, delivered by J. Ruskin, Esq., M.A., in the Theatre of the R.A. Institution	100	J. Ruskin, Esq., M.A.
Report on the Intercolonial Railway Exploratory Survey	1	Colonel F. Haultain, R.A.
Report on the state of the Militia of the Province of Canada	1	Colonel F. Haultain, R.A.
Manufacture and Composition of Gun Cotton, by F. A. Abel, Esq., F.R.S., &c.	1	The Author.
Words of Command employed in Manœuvring a Regiment of Cavalry, a battalion of Infantry, and a battery of Artillery, by Lt. H. W. L. Hime, R.A.	1	The Author.
Kane's List of Officers, R.A., 1815	1	Colonel Barnes, late St Helena Regiment, through Captain J. L. Clarke, R.A.
Garrison Carriages for Sea Lines and Barbet batteries, with platforms and stands for firing over Parapets and Fortifications, by Capt. Robert Lawson, R.A.	1	Colonel Barnes, late St Helena Regiment, through Captain J. L. Clarke, R.A.
Artillery Memoranda relative to the Royal Navy, by Capt. Robert Lawson, R.A., 1782	1	Colonel Barnes, late St Helena Regiment, through Captain J. L. Clarke, R.A.
Sketch illustrating the distribution of the men, women, and children, who dined on the barrack field, Woolwich, on the Coronation of George IV.	1	Colonel Barnes, late St Helena Regiment, through Captain J. L. Clarke, R.A.
Photographs of a subdivision of the Armstrong mountain battery, with 20 rounds of ammunition, as prepared for the second Bhootan Campaign	4	Captain C. W. Wilson, R.A.
Photographs of a division of the Armstrong mountain battery	3	Captain C. W. Wilson, R.A.
Pamphlets on Tilting Lances, and Jousting Vamplates of the 16th Century, by J. Hewitt, Esq.	2	The Author.
Operations of the War in 1866, by Major F. Miller, VC., R.A.	1	The Author.
Catalogue of the Professional Libraries of the Royal Engineers	1	Gen. Sir J. F. Burgoyne, Bt., G.C.B., R.E.
Experiments with Naval Ordnance, H.M.S. "Excellent," 1866	1	Capt. Cooper, Key, C.B., R.N.
Catalogues of Lepidopterous insects, birds, and mammals, in the Museum of the Honourable East India Company	4	F. Moore, Esq., through Mr H. Whitely, Sen.

Journal of the Royal Geographical Society, Vol. XXXV.	1	Royal Geographical Society.
Proceedings of the Royal Geographical Society, Parts 1, 2, 3, 4, 5, 6, Vol. X., Part 1, Vol. XI.	7	Royal Geographical Society.
New South Wales Gazetteer, 1866	1	Government of N.S. Wales.
A few Stray Thoughts upon Shakespear, by T. Howell	1	The Author, through Lt.-Col. T. W. Milward, R.A.
Plans of Woolwich Warren, and Plumstead Common, A.D. 1741	2	Lt.-Gen. C. F. Fox, F.R.G.S.
Professional papers of the Corps of Royal Engineers, Vol. XV.	1	Major C. S. Hutchinson, R.E.
Photographs of Welsh Scenery	6	Major C. E. Burt, R.A.
Photographic view of Kingston, Canada west, and groups of officers 10th Brig., R.A.	4	Major C. E. Burt, R.A.
Photographic views of Gibraltar	7	Lieut. A. B. Brown, R.A.
Despatches of Field Marshal the Duke of Wellington, 1799 to 1818	13	Lt.-Col. H. Chermside, R.A.
Code Napoleon (French and German)	1	Lt.-Col. H. Chermside, R.A.
Steel plate engraving of George Augustus Elliot, Lord Heathfield, Governor of Gibraltar	1	Lt.-Col. H. Chermside, R.A.
Inorganic and Organic Chemistry, with experiments, by C. L. Bloxam	1	The Author.
The Meteoric Theory of Saturn's rings, by S. M. D., R.A.	1	The Author.
Short sketch of the Campaign in Austria of 1866, by Lt.-Col. A. C. Cooke, R.E.	1	The Author.
Report of Dutch Artillery Practice	1	Netherlands Government.
Illustration of the piece of Plate, presented to the Duke of Richmond in 1851, by the recipients of the War Medal	1	Lt.-Gen. H. Sandham, R.E.
Pamphlet on Revolution and Rotation, by H. Perigal, Jun.	1	The Author.

Books purchased.

Roget's Thesaurus of English Words and Phrases. One Vol.
Promptorium Parvulorum, by Albert Way. One Vol.
Histoire de l'Artillerie. One Vol.
Gunnery Instructions. Part 1, Great Guns, 1864. One Vol.
The Operations of War explained and illustrated by Colonel E. B. Hamley, R.A. One Vol.
Gould's Humming Birds. Parts 8, 9, 10, 11, 12, 13, 14, 15, 18, 22, 23, 24, 25.
" Birds of Asia. Part 18.
" Birds of Great Britain. Parts 9 and 10.
A Brief Biographical Dictionary, by Charles Holt. One Vol.
The Ibis. Parts 7 and 8, Vol. II., and Part 9, Vol. III.
Histoire de Jules César. Vol. II.
The Naturalist in British Columbia, by J. K. Lord, F.Z.S.
Exotic Butterflies, by W. C. Hewitson. Parts 21 to 40.
Duckett's Military Dictionary. One Vol.

Royal Warrant, Pay. February 1866. One Vol.
Revue de Technologie Militaire. Part 2, Vol. V.
Das Keerwesen des Osterreichischen Kaiserstadtts. Two Vols.
Electro Ballistic Machines and the Schultz Chronoscope, by Benet. One Vol.
Nautical Almanac, 1867.
Todhunter's Plane Trigonometry. One Vol.
Self-supporting Folio for holding plates, published by Arundel Society.
Map "Die Deutchland."
Lemmi's Italian Grammar, 6 copies
Bibliotica D'Antori, 6 copies ..... } For Italian Class.
Baretti's Italian Dictionary, 2 copies
Catalogue of National Portraits, ending with the reign of King James II., on loan to the South Kensington Museum, April 1866. One Vol.

List of Periodical Publications.

Journal de Mathématiques
Journal des Armes Spéciales.
Comptes Rendus.
Crelle's Journal.
Le Spectateur Militaire.
Practical Mechanic's Journal.
Philosophical Magazine.
Journal of the Society of Arts.
The Geological and Natural History Repertory.
British Journal of Photography.
The Photographic News.
Jackson's Woolwich Journal.
The Times.
Engineering.

Arundel Society Plates.

The Adoration of the Magi. | The Last Supper.

5. *Museum.*—The donations during the past year to all departments of the Museum have been very numerous, and in many instances are of considerable value. In Ornithology there have been presented by Lieut. Hutchinson, R.A. and Mr Whitely, some fine specimens of birds from Japan, four of these have been set up in separate glass cases on account of their beauty and rareness; by Lieut.-Col. Chermside, R.A., some valuable specimens from the Cape.

The Committee have especial pleasure in calling attention to the additions made to the collection of British birds, which had previously progressed but slowly; in this section the Institution is indebted to Lieut. Legge, R.A. for a fine series of gulls and other aquatic birds—some specimens of the former being specially interesting and valuable from their immature state, thus affording illustrations of the change of plumage. Captain Slessor, R.A., Lieut. Bainbridge, R.A., and Lieut. Broadrick, R.A., have also contributed to this branch.

The collection of eggs has been increased by handsome gifts from Lieut. Legge, R.A., and Lieut. O'Grady, R.A., and some valuable specimens were purchased at the sale of the late Gordon Cumming's collection.

In insects, a local collection from Gibraltar presented by Lieut. G. S. Parry, R.A., is worthy of notice, as also a very fine series of specimens from India, contributed by W. Rawes, Esq. 100 Coleoptera from Japan have been purchased, but the specimens being new to this country have not yet

been named, and therefore it has not been possible to prepare a catalogue for this Report.

In conchology the donations have been very rich. Through the liberality of Lt.-Col. Freeth, R.A. the museum has become possessed of a fine cabinet of shells containing many hundred specimens which were collected and arranged by his father the late Sir James Freeth, K.C.B.; and contributions have also been made by Captain C. L'Estrange, R.A., and by Lieutenant Annesley, R.A., from Mauritius and Aden respectively.

Major Andrews has presented some valuable geological specimens; and Colonel Woollcombe, C.B., R.H.A., and Lieut.-Col. Anson, R.A., have contributed many miscellaneous objects of interest from Aden and Madagascar.

A collar of Bandoliers of the 17th Century, kindly presented by J. Hewitt, Esq., deserves mention from its rareness, and to that gentleman and Capt. H. Brackenbury, R.A. the best thanks of the Committee are due for naming and arranging the ancient fire-arms and other weapons belonging to the Institution.

Presentations to Museum.

British Bird	1	Lieut. R. Walkey, R.A.
Collar of Bandoliers of the 17th Century	1	J. Hewitt, Esq.
Paddle from Madagascar	1	Captain W. Rooke, R.A.
Sword and spear from Abyssinia	2	Lt. O. F. T. Annesley, R.A.
Box of shells, reptiles, and geological specimens from Aden	1	Lt. O. F. T. Annesley, R.A.
Albatross and Snake's skin	2	Lt. O. F. T. Annesley, R.A.
Collection of Insects and Butterflies from Gibraltar	...	Lieut. G. S. Parry, R.A.
Sabre, Cavalry, temp., George III.	1	Captain T. L. Dames.
" Officers, "	1	Captain T. L. Dames.
" " early, George III.	1	Captain T. L. Dames.
" Cavalry, "	1	Captain T. L. Dames.
Pistols, Flint	8	Captain T. L. Dames.
Carbine, Cavalry, temp., George III.	1	Captain T. L. Dames.
Blunderbusses	2	Captain T. L. Dames.
Tomahawk, North American	1	Captain T. L. Dames.
Collection of Shells from Mauritius	...	Captain C. L'Estrange, R.A.
Reptiles from India	...	Captain H. J. Thornton, R.A.
Australian Bird	1	Lieut. H. R. L. Morgan, R.A.
Collection of Fossils, from Sheppey, Lyme Regis, and Whitby	32	Major W. G. Andrews, R.A.
Grape shot from No. 9 Redoubt, Düppel	1	Lieut. C. S. Harvey, R.A.
Austrian Galvanic Fuzes	2	Lieut. C. S. Harvey, R.A.
" Gun Cotton Cartridge	1	Lieut. C. S. Harvey, R.A.
Danish Friction Tube	1	Lieut. C. S. Harvey, R.A.
Piece of Experimental American Mining Fuze	1	Lieut. C. S. Harvey, R.A.
Flint Arrow Head from Co. Donegal	1	Lieut. C. S. Harvey, R.A.
Specimen of Stag Beetle	1	Col. E. Wodehouse, C.B., R.A.
Specimen of Bitumen from the Pitch Lake, Trinidad	1	Lieut. J. F. Owen, R.A.
Specimen of Mole	1	Lieut. J. F. Owen, R.A.

Fish's Tail, 9 ft. 9 in. long	1	Lieut. F. Weston, R.A.
Parts of Shell, called in Malay, "Matta Limboo," or "Bullock's Eye"	3	
Malay "Ladding" or Sword	1	
Pair of Chinese Chopsticks	1	
Chinese Fiddle	1	
" Guitar or Banjo	1	
" Bows	2	
Pheasants from Japan	4	Lt. W. L. Hutchinson, R.A.
Japanese Umbrellas	2	
Boxer Cartridge for the Snider converted Enfield Rifle, whole, section, and in different stages of manufacture	2	Capt. V. D. Majendie, R.A.
Specimen of Cheer Pheasant	1	Capt. M. Fitzgerald, R.H.A.
Swords from Madagascar	5	Lt.-Col. A. E. H. Anson, R.A.
Spear Shafts from Madagascar	2	
Poles used in Madagascar for digging	3	
Implement used by the Natives of Madagascar in weaving	1	
Piece of Cloth of Native manufacture	1	
Piece of Raw Silk from Madagascar	1	
Piece of Rope made from Rush	1	
Padlocks of Madagascar manufacture	2	
Pairs of scales and weights do	2	
Snuff boxes do	4	
Horn spoons do	3	
Wooden do do	3	
Sewing needle do	1	
Gold lace cap, worn by the Prime Minister of King Radama II.	1	
Pair of steelyards	1	
Dodo bones	2	
Collection of Turtle Bones		
Photographs of Order and Diploma given to Lt.-Col. Anson, R.A., by Radama II. King of Madagascar	3	
Piece of the first shell fired at the Siege of Sebastopol	1	Major C. R. Shervington, late 46 Regt.
Birds from India	3	Lieut. B. J. Bonnor, R.A.

From the Battlefield of Königgrätz, 3rd July 1866 :—

Austrian Cap Pocket	1	Lt. G. B. B. Hobart, R.H.A.
" Shako Plate	1	Lt. E. F. Chapman, R.H.A.
" Bag	1	Lt.-Col. W. E. M. Reilly, C.B. R.H.A.
Birds' nests, with birds from Western Africa	4	Mr H. Whitely, Sen.
Specimen of glass coral from Japan	1	
Shell from the Pacific	1	
Female pheasants from Japan	2	
Waterproof coat, made from fish skins, by the natives of Sitka, Russian North America	1	Mr H. Whitely, Jun.
Birds from Japan	3	

Austrian shrapnel shells, purchased at Chlum, 26th September, 1866	2	Lieut. J. P. Nolan, R.A.
Piece of Austrian shell obtained at Nachod, 27th September, 1866	1	
Part of Prussian ammunition from Chlum	1	
British Birds	29	Lieut. W. V. Legge, R.A.
" Birds' Eggs	29	
" Birds	3	Lieut. E. Bainbridge, R.A.
" "	4	Captain E. A. Slessor, R.A.
Collection of 20 Geological specimens from the Rock of Gibraltar, arranged in case	1	Lieut. A. B. Brown, R.A.
Stalactite from Gibraltar	1	
Specimen of Russian prismatic powder	1	Capt. F. G. E. Warren, R.A.
Russian friction tube, complete	1	
" " in parts	1	
" concussion fuze	1	
Silver coins, Russian, French, &c.	23	
Copper " "	19	
Teeth of sloth bear	4	
Bullets found embedded in the flesh of a tiger, killed by Captain Warren and Lieut. Cruttwell, R.A.	2	
Segment of an Armstrong shell picked up inside the Tassagong stockade, Bhootan.	1	
Bhootea Rupee	1	
" Anna	1	
Iron relic, dug up during the experiments at Newhaven in 1863, in association with Roman pottery	1	Captain W. H. Noble, R.A.
Indian Topee	1	Serjt.-Major W. White, R.A.
South African hunting spear	1	
New Zealand spear	1	
Specimens of woods from New Zealand	15	Captain J. F. Betty, R.A.
Specimen of iron sand from the shores of New Zealand	1	
Fossil shells from New Zealand	...	
Ghoorka knife	1	Lieut. R. W. Smith, R.H.A.
Spherical bullets of Maori manufacture, and recovered English rifle bullets from New Zealand	...	Captain W. G. Martin, R.A.
Shells from the Gulf Stream	4	Colonel S. Freeth, R.E.
Collection of insects and reptiles		W. Wilson Rawes, Esq.
Cabinet of shells	1	Lieut.-Col. R. K. Freeth, R.A.
Cases of Natural History	2	
Collection of minerals	1	
Tiger skin from India	1	Lt.-Col. E. Wray, C.B., R A.
Flint implements of modern manufacture	3	J. Tennant Esq., F.G.S., &c.
British birds	4	Lieut. E. Broadrick, R.A.
Egg of Woodcock, taken in the New Forest	1	Captain A. W. Drayson, R.A.
Squirrels	2	
Robin's nest	1	Capt. T. A. J. Harrison, R.A.
British mole	1	
Specimens of British beetles	...	

Specimens of iron stone	2	Maj. H. J. F. E. Hickes, R.A.
Soomali spears, made from Antelope's horns	2	
" war clubs	4	
" spears	2	
" knife	1	
" carved spoons	8	
" pillow	1	
" shield	1	
Abyssinian spear	1	
" sword	1	
" shield	1	
Arab matchlock	1	
" dagger or jambea	1	Col. J. D. Woollcombe, C.B. R.H.A.
" belt and pouches	1	
" sword	1	
Elephant's tusk	1	
Strombus shells	2	
Lioness' skin	1	
Leopard's skin	1	
Hippopotamus's tusks	2	
Tusks of African wild boar	2	
Ostrich's eggs	2	
Pairs of Soomali shoes	2	
Soomali wig	1	
" combs or head ornaments	4	
Specimen of Arab gunpowder	1	
Kaffir, "Knob-Kerries," from Cape of Good Hope	2	
Kaffir Assegais, from Cape of Good Hope	6	
Pipe-bowls, made from the Orange river green-stone by the Boers, or Dutch Emigrant Farmers of the Orange Free State	2	Lt.-Col. H. Chermside, R.A.
Wooden pipes, inlaid with lead, made by the Eastern frontier Cape Kaffirs	3	
Basket made by do	1	
Birds from Cape of Good Hope	9	
Collection of shells from the mouth of the Buffalo river, S. Africa	...	
Specimen of native sulphur from Naples	1	Lieut. W. J. Tatham, R.A.
Bottle of port, recovered from the wreck of the "Royal George," by General Sir Charles Pasley, K.C.B., R.E.	1	Lt.-Gen. H. Sandham, R.E.

British Birds, presented by Lieut. Legge, R.A.

Tinnunculus alaudarius, Kestrel, 2 specimens.
Charadrius hiaticula, Ringed plover, 2 do.
Ardea cinerea, Common heron.
Numenius arquata, Common curlew, 2 specimens.
Totanus calidris, Redshank.
Tringa alpina, Dunlin.
Gallinago gallinula, Jack snipe.
Rallus aquaticus, Water rail.
Bernicla brenta, Brent goose.
Fuligula marila, Scaup duck.
Nyroca ferina, Pochard.
Clangula glaucion, Golden-eye.
Harelda glacialis, Long tailed duck, 2 specimens.
Colymbus glacialis, Great northern diver.
C. septentrionalis, Red throated diver.
Larus glaucus, Glaucous gull.
L. leucopterus, Iceland gull.
L. argentatus, Herring gull, 3 specimens.
L. canus, Common gull.
L. ridibundus, Black headed gull.
Rissa tridactyla, Kittiwake.
Sterna minuta, Lesser tern.
Graculus carbo, Cormorant.
G. linnæii, Shag.

29 Species of British birds' eggs.

British Birds, presented by Lieut. Bainbridge, R.A.

Cotyle riparia, Sand martin. | Cinclus interpres, Turnstone.
Clangula glaucion, Golden-eye.

British Birds, presented by Captain Slessor, R.A.

Rallus aquaticus, Water rail. | Alca torda, Razor-bill.
Oidemia nigra, Common scoter. | Rissa tridactyla, Kittiwake.

British Birds, set up and presented by Lieut. E. Broadrick, R.A.

Dafila acuta, Pin-tailed duck. | Numenius arquata, Common curlew, 2 specimens.
Accipiter nisus, Sparrow hawk.

Presented by Lieut. Walkey, R.A.

Picus major, Great spotted woodpecker.

Presented by Lieut. Bonnor, R.A.

Gallus sonneratii ♂ ♀ | Hydrophasianus sinensis ♂

Presented by Captain Fitzgerald, R.H.A.

Phasianus, wallichii ♂

Presented by H. Whitely Jun., Birds from Japan.

Garrulus brandtii. | Pluvalus orientalis.
Larus melanurus.

Presented by W. Rawes, Esq.

Insects and reptiles from India.

Presented by Captain Drayson, R.A.

Egg of woodcock taken in the New Forest. | 2 Squirrels (sciurus vulgaris).

Presented by Captain Harrison, R.A.

Robin's nest. | Mole (talpa vulgaris).
Specimens of British beetles.

Presented by Lieut. O. F. F. Annesley, R.A. from Aden.

Shells, rocks, coral, two saws of saw fish, &c. | Albatros (diomedea exulans), and snake skin.

Presented by Lieut. F. L. Weston, R.A.

Fish tail, &c.

Presented by Captain C. L'Estrange.

Fine collection of shell from the Mauritius.

Presented by H. Whitely.

Voluta coronata.
Phasianus sœmmeringii ♀
Phasianus versicolor ♀
Glass coral from Japan.

Presented by Lieut. Hutchinson, R.A. from Japan.

Phasianus sœmmeringii ♂
P. versicolor ♂
Thaumalea picta ♂
Aix galericulata ♀

Presented by Lieut. G. S. Parry, R.A.

Collection of Lepidoptera and Coleoptera from Gibraltar.

Presented by Lieut.-Colonel R. K. Freeth, R.A.

28 Draw cabinet of shells, many of which are rare; this is a very valuable addition to the mollusca of the Museum.
2 Cases with crab, lizard, platipus, &c., and also a few minerals.

Presented by Colonel J. D. Woollcombe, C.B., R.H.A. from Aden.

Lion skin.
Leopard do
Tusks of hippopotamus and wild boar.
2 Shells.

Presented by Lieut.-Colonel H. Chermside, R.A., Birds from the Cape.

Musophaga persa, 3 specimens.
Psittacus levaillantii, 2 specimens.
Oriolus.
Cuculus auratus, 2 specimens.
Lamprotornis.

British Birds' Eggs, collected principally in Surrey, presented by Lieut. R. W. O'Grady, R.A.

Tinnunculus alaudarius.
Accipiter nisus.
Strix flammea.
Caprimulgus europæus.
Hirundo rustica.
Chelidon urbica.
Certhia familiaris.
Troglodytes parvulus.
Calamodyta phragmitis.
Luscinia philomela.
Sylvia curruca.
Sylvia cinerea.
Sylvia atricapilla.
Sylvia hortensis.
Sylvia trochilus.
Sylvia rufa.
Regulus cristatus.
Pratincola rubetra.
Saxicola ænanthe.
Ruticilla phœnicura.
Erythacus rubecula.
Accentor modularis.
Parus major.
Parus caudatus.
Mortacilla yarrellii.
Mortacilla campestris.

Anthus arboreus.
Turdus viscivorus.
Turdus musicus.
Turdus merula.
Muscicapa atricapilla.
Muscicapa grisola.
Enneoctonus collurio.
Garrulus glandarius.
Pica caudata.
Corvus frugilegus.
Corvus monedula.
Sturnus vulgaris.
Fringilla cælebs.
Fringilla carduelis.
Fringilla chloris.
Linota cannabina.
Passer domesticus.
Passer montanus.
Emberiza schœniclus.
Emberiza citrinella.
Emberiza cirlus.
Alauda arvensis.
Pyrrhula rubicilla.
Picus minor.
Yunx torquilla.
Columba palumbus.
Columba œnas.
Turtur auritus.
Phasianus colchicus.
Perdix cinerea.
Vanellus cristatus.
Charadrius hiaticula.
Ardea cinerea.
Totanus calidris.
Gallinula chloropus.
Fulica atra.
Podiceps minor.
Larus ridibundus.

British Birds Eggs, presented by Lieut. Legge, R.A.

Syrnium aluco.
Calamodyta strepera.
Calamodyta phragmitis.
Luscinia philomela.
Sylvia cinerea.
Ruticilla phœnicura.
Accentor modularis.
Parus major.
Parus cæruleus.
Turdus musicus.
Turdus merula.
Muscicapa grisola.
Enneoctonus collurio.
Garrulus glandarius.
Pica caudata.
Corvus corax.
Corvus frugilegus.
Corvus monedula.
Corvus corone.
Sturnus vulgaris.
Fringilla chloris.
Linota cannabina.
Passer domesticus.
Alauda arvensis.
Columba palumbus.
Caccabis rufa.
Totanus calidris.
Gallinula chloropus.
Fulica atra.

List of Eggs purchased at the sale of the late Gordon Cumming's collection.

Upupa epops.
Calamodyla palustris.
Cyanecula suecia.
Pastor roseus.
Fringilla montifringilla.
Coccothraustes vulgaris.
Plectrophanes nivalis.
Loxia curvirostra.
Œdicnemus crepitans.
Charadrius minor.
Limosa melanura.
Strepsilas interpres.
Gallinago major.
Ortygometra bailloni.
Anser albifrons.
Anser gambensis.
Anser ferus.
Cygnus olor.
Cygnus immutabilis.
Tadorna vulpanser.
Mareca penelope.
Fuligula marila.
Clangula vulgaris.
Harelda glacialis.
Mergus merganser.
Mergus albellus.
Podiceps cornutus.
Uria ringvia.
Uria brunnichii.

List of Fossils, presented by Major W. G. Andrews, R.A.

Xanthopsis Leachii.
Teeth of Otodus obliquus.
Skull of Chelone longiceps.
Ammonites bifrons. Whitby (Lias).
" oxynotus. "
Plastron of Chelone longiceps.
Belemnites. (L. Lias) Lyme Regis.
" apicicurvatus. (L. Lias) Lyme Regis.
Hoploparia grammaroides.
Halecopsis lævis.
Nautilus striatus. (L. Lias) Lyme Regis.
Fragment of Septaria, with fossil wood bored by Teredo Antenantæ.
Fish vertebræ.
Ammonites communis.
" sp.
Nautilus imperialis.
Cybium macroponum.
Lima gigantea. (L. Lias).
Sphyrænodus priscus.
Nipadites Parkinsonis.
Fossil wood, bored by Teredo Antenantæ.
Carapace of Chelone longiceps.
Xantholites Bowerbankii.
Gryphæa meurva, (L. Lias).
Ammonites lenticularis.

6. *Taxidermy.*—This class has met regularly twice in each week, and has been very well attended.

7. *Languages.*—The French and German classes, which are free of charge to Members, have met as usual. Instruction has also been provided in Italian for a large class of Officers.

8. *Mathematics.*—At the request of a few Officers a Mathematical class was formed and met for a short time during the past year.

9. *Drawing.*—The Drawing Class has always been full, the present instructor, Mr Needham giving great satisfaction, and from the number of Officers attending the class it has been necessary to have two attendances each week. To meet the wishes of some Members, the Committee have sanctioned the use of the Class Room for two hours weekly to enable Mr Needham to give instruction to ladies belonging to the families of Members.

10. *Surveying and Practical Astronomy.*—During the past year several Officers have availed themselves of the gratuitous instruction which is obtainable by Members on these subjects.

A 4″ telescope has been mounted at the Observatory. Monthly notices are issued notifying the Astronomical Phenomena which occur during each month, and Captain Drayson has frequently attended to afford information on the subject. The instrument is sufficiently large to show the satellites of Jupiter, and Saturn's rings.

11. *Photography.* Five Officers have received instruction in Photography since the last report. 1000 negatives have been taken during the year, from which over 10,000 copies have been printed.

Two new lenses have been purchased, viz. a group lens, and a new wide angle lens for taking interiors and landscapes; and a small sum has been expended on accessories, and in making certain additions to enable photographs to be taken at either end of the room. This department of the Institution is now very complete, and the Committee have therefore felt justified in reducing the charge hitherto made for photographs, from 6s. to 5s. a dozen for cartes-de-visite size, and from 24s. to 18s. a dozen whole plate size.

Thanks are due to Capt. John Stirling, R.A. for lending a number of views in New Zealand for copying, and also to Lieut. A. B. Brown, R.A. for some photographs of Gibraltar, thus increasing the collection of views of Foreign Stations.

12. *Instruments.*—Some deficiencies which existed in the excellent microscope, presented to the Institution by the late Sir R. Gardiner, have been supplied at a cost of £6, and it may now be considered complete as an instrument intended for general use. The articles purchased consist of a polarizing apparatus,—absolutely necessary, as many of the objects in the Cabinet are specially intended to be viewed by polarized light;—an objective carrier, to enable two object glasses to be conveniently used; and an objective ⅔″, to fill up an inconvenient gap which existed in the range of powers. Lt.-Col. Miller, R.A. has performed a most useful work in drawing up some simple instructions for using the microscope, and has also made a list of all the objects in the cabinet; both of which the Committee have caused to be printed. It has also been decided that if two or three Members at any home station express a wish to have the microscope on loan, it shall be forwarded to the care of any individual Member who is willing to take charge of it. The instrument is not to be retained more than one month at a Station. This arrangement will place the microscope within reach of Members who are away from Woolwich, and the Committee feel that they are thus carrying out one of the main objects of the Institution, by providing facilities for intelligent occupation and study.

13. *Lectures.*—In addition to the regular course of Lectures which have been delivered to the Advanced Class of Artillery Officers by Professor Bloxam, F.C.S., and by Dr Percy, F.R.S., those enumerated in the following list have been given on Wednesday Evenings during the winter, and the Committee desire to express their thanks to Mr Abel, The Rev. J. Bellew, Lt.-Col. Miller, V.C. R.A., Mr Owen, and Col. F. Eardley-Wilmot, R.A., F.R.S., for the gratuitous service thus rendered.

The Committee are glad to be able to publish with this Report, Lieut.-Colonel Miller's excellent Lecture on the Bohemian Campaign, the manuscript of which he has been good enough to place at their disposal for the purpose.

J. H. Pepper, Esq., F.C.S.	On the Phenomena of Polarized Light.
Charles Salaman, Esq.	Musical Lecture on Beethoven and his Compositions.
The Rev. J. Bellew	The following Readings:—Horatius, Horatio Sparkins, Clarence's Dream, Cox's Diary, The Charge of the Light Brigade at Balaclava.
The Rev. C. B. Power, M.A., F.C.S.	The Philosophy and Phenomena of Sound, in relation to the Physics of Music and Musical Instruments.
Lieut.-Colonel F. Miller, V.C., R.A. ...	The Campaigns of 1866 in Bohemia and along the Maine.
William Stokes, Esq.....	Memory, and its Cultivation.
Colonel F. Eardley-Wilmot, R.A., F.R.S.	The Mariner's Compass.
Sidney Owen, Esq, ...	The British Conquest of the Carnatic.
F. A. Abel, Esq., F.R.S., Chemist to the War Department	Recently proposed Substitutes for Gunpowder.

14. *Model Room.*—Specimens of all projectiles adopted into the Service during the past year have been kindly presented by the Secretary of State for War.

List of Service Projectiles, &c., presented to the Institution, by H. M. Government.

Parachute light balls, 10″, 8″, and 5½″, and section of 10″ with fuze.....	4	Specimens of iron cast in chill	2
Wood time fuzes for do do	3	Electric tubes	2
Rifle musket, Enfield pattern 1853, converted on Snider plan to breech-loader, with ramrod and bayonet	1	Pettman's general service percussion fuze	1
		Reeves' case shot for 9″, 7″, and 12 or 9-pr. guns.....	3

In compliance with Rule V. the following Officers retire from the Committee, and are not eligible for re-election:—

Colonel W. Gardner, Capt. Bruce, Capt. Molony, Major Hickes.

The following Members have also left the Garrison, and the vacancies thus occasioned have been filled up by the Committee, subject to the approval of the General Meeting:—

Captain Anley,	by	Captain F. Whinyates.
" Sandham,	"	" Noble.
Lieut. J. M. Murray	"	Lieut. Marshall.

Surgeon-Major Combe, M.D. has been elected *vice* Surgeon-Major Litle, A.B. deceased.

The following resolutions were passed:—

1. *Proposed by Colonel J. M. Adye, C.B., seconded by Lieut.-Colonel G. T. Field, and carried,—*

"That the Report of the Committee be adopted and printed."

2. *Proposed by Committee, seconded by Lieut.-Colonel Gosling, and carried unanimously, that the following additions be made to No. II.* of the Rules.*

After 10s. 6d. to add:—

Officers doing duty with the Ordnance Select Committee, other than those of the Royal Artillery, to be *ex-officio* Honorary Members during the time they are thus employed, and may obtain the periodical publications of the Institution free of charge.

3. *Proposed by the Committee, seconded by Captain A. H. Hutchinson, and carried unanimously,*

At the end of the same Rule to add:—

The Committee may submit to the Annual Meeting, the names of gentlemen, whether Officers in the Army or Navy, or Civilians, for election as special Honorary Members of the Institution, and the Annual Meeting shall have power to elect any or all of the gentlemen whose names are thus submitted, provided always that the total number of special Honorary Members shall not at any one time exceed twenty, and further that the names of all gentlemen to be thus proposed for election shall have been exhibited at the Institution for fourteen days previous to the General Meeting. Gentlemen thus elected, to receive the periodical publication of the Regiment without any payment.

The undermentioned gentlemen were then elected special Honorary Members:—

F. Abel, Esq., F.R.S.	T. Hewitt, Esq., F.S.A.
Sir Wm. Armstrong, C.B.	R. Mallet, Esq., F.R.S.
Rev. F. Bashforth, B.D.	Major Palliser.
Dr Fairbairn, F.R.S.	Dr Percy, F.R.S.
Captain H. W. Gordon, C.B.	J. Whitworth, Esq.

4. *Proposed by Committee, seconded by Lieutenant-Colonel Field, and carried unanimously,—*

"That No. V.† of the Rules and Regulations of the R.A.I. be amended as follows, after "Officers," insert:—

"The President Ordnance Select Committee" (when a member).

5. *Proposed by Lieut.-Colonel Field, and seconded by Colonel Adye, C.B.—*

"That the Director of Ordnance be added to the list of Vice Presidents."

It was decided by the Chairman that this motion is not in order, notice not having been given as required by Rule XVIII. But the Secretary was requested to communicate the sense of the General Meeting in favour of the motion to the Committee, with a view to their consideration of it for confirmation at the next Annual Meeting.

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* II Officers of the Royal Engineers, and of the Militia Artillery, and professors and masters of the Royal Military Academy, are eligible to become Honorary Members. They may obtain the periodical publications of the Institution, on the annual payment, in advance, of the sum of 10*s.* 6*d.*

† V. The Commander-in-Chief to be Patron and President of the Institution. The Commandant of the Garrison, and the Deputy Adjutant-General, to be Vice-Presidents. The affairs of the Institution to be under the direction of a Committee, consisting of the above Officers, &c.

6. *On the motion of Colonel Adye,—*

A discussion ensued on the propriety of a re-publication of Kane's List, and the sense of the General Meeting was decidedly in favour of this publication, on condition that a guarantee Fund to the amount of the cost of the work can be raised among Members to prevent loss to the funds of the Institution. Brig.-General Lefroy, Colonel Adye, Colonel H. Goodenough, Lieut.-Colonel Gosling, Lieut.-Colonel Field, Major Young, Captain Harrison, and Captain Brackenbury, have entered their names on the Guarantee Fund.

7. *Proposed by Brig.-General Lefroy, seconded by Lieut.-Colonel Gosling, and carried unanimously,—*

"That the thanks of the Meeting be voted to the Secretary for the manner in which he has performed his duties during the past year."

8. *Proposed by Lieut-Colonel Field, seconded by Major Young, and carried unanimously,—*

"That the thanks of the Meeting be voted to the Chairman."

The Committee for the current year will stand thus:—

PATRON AND PRESIDENT:

Field Marshal H.R.H. the Duke of Cambridge, K.G.

VICE PRESIDENTS:

The Commandant.
The Deputy-Adjutant-General.

MEMBERS:

The President Ordnance Select Committee.
The Assistant-Adjutant-General.
The Secretary Ordnance Select Committee.
The Brigade-Major.
The Director of Artillery Studies.

Colonel J. Adye, C.B.
" Wodehouse, C.B.
" Younghusband.
" C. V. Cox.
Surg.-Major Combe, M.D.
Lieut.-Colonel Miller, VC.
Captain C. O. Browne.
" C. V. Arbuckle.
Captain Traill.
" F. Whinyates.
" Noble.
" C. E. Scott.
Lieut. Sladen.
" Marshall.
" R. Walkey.

Captain T. A. J. Harrison, *Secy. and Treasurer.*

(Signed) J. H. LEFROY, Brig.-General.
In the Chair.

May 6, 1866

A LECTURE

ON

THE CAMPAIGNS OF 1866 IN GERMANY.

BY LIEUT.-COLONEL F. MILLER, R.A., VC.

" Sua cuique exorsa laborem
" Fortunamque ferent. Rex Jupiter omnibus idem.

ÆNEID X. 3.

Prefatory Remarks.

On the 1st December 1866, I received an application from the managers of the "London Institution," to give a lecture on the late war in Germany at their next *soirée*, on the 19th of the same month. They apologized for asking me to do so at such short notice, and explained it by their having been disappointed in other arrangements originally proposed for that evening. The interval was barely sufficient for writing such a lecture, and executing the diagrams required to illustrate it, even by devoting every possible hour to the task; the time was quite inadequate for preparing the account with all the care which the occasion deserved. I pointed out this objection, but undertook to meet their wishes, if doing so would relieve them from any embarrassment. The managers accepted the offer, and courteously acknowledged their obligations for the service.

The London Institution was founded in 1806, to occupy in the east of London the same position, as an establishment for the encouragement and prosecution of science, which the Royal Institution fills in the west. Courses of scientific lectures are regularly given, and at the monthly *soirées* held in the winter season, lectures are delivered on topics of current interest. Military subjects had rarely or never before been introduced.

Having to address unmilitary listeners, I avoided as far as possible all military terms, and all reference to points of purely professional importance. No other occasion for delivering the lecture was anticipated, and it was only by accident that such an occasion arose.

Major Adams, the instructor in military history at the Royal Military College, Sandhurst, had kindly promised to undertake this subject in the

course of lectures arranged by the Committee at the Royal Artillery Institution, but ill health prevented him from fulfilling the engagement. To prevent the members from being entirely disappointed, I offered this as an imperfect substitute for his account, and made such alterations as could then be introduced, to make it more suitable for a military audience. It was received more favourably than I could have anticipated, and is now printed by desire of the Committee, to form part of the Institution "Proceedings." I have added a few notes and several references to sources of further information to give it a little more value. I must however express my regret that the Institution was deprived of Major Adams' remarks; for he has formerly served in the Austrian army, he has visited the scene of the campaign, and he has been for many years professionally employed in treating the subjects which I myself have but desultorily taken up.

Preliminary Operations.

The first episode of the war was a simultaneous invasion by Prussia of three independent states, carried out with a promptitude which took the world by surprise. Austria had brought forward a motion in the German Diet which was fairly interpreted by Prussia as an act of hostility against her. On the 14th June it was carried, and among the majority were Saxony, Hanover, and Electoral Hesse. Immediately Prussia called on these three states to place their troops on a peace establishment, and to accept her proposition for reform of the Confederation. The alternative was war, and only twelve hours were allowed for deliberation. The states returned a refusal; war was therefore declared on the evening of the 15th June, and in course of the next day each of them was invaded by Prussian troops.

Electoral Hesse fell victim to a force composed of troops collected from various garrisons and assembled at Wetzlar under General Von Beyer. Hanover was entered by General von Falkenstein from Minden (on the west) and by General von Manteuffel from Sleswig (on the north); the two columns uniting in the capital of the kingdom. Saxony was in like manner entered and reduced by General Herwarth von Bittenfeld. In each case the army of the country was unprepared for resistance, and fell back before the invaders. The Hessians succeeded in uniting themselves to the federal troops assembling at Frankfort, and the Saxons took shelter in Bohemia. The Hanoverians marched towards Bavaria, but were not equally fortunate in escaping their pursuers.

Thus, within a few days, Prussia had won great success. She had established a connection with the Rhenish provinces, which were before cut off and isolated from the rest, and she had excited some wholesome respect for her readiness in action. She had also acquired possession of certain lines of railway which very much improved the means of communication throughout the tract of country where her main forces were posted.*

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* The direct line of railway between Halle, in Prussian Saxony, and Breslau in Silesia runs through Dresden, the distance being about 225 miles. So long as this line was closed the only railway communication was round by Berlin, which lies a hundred miles north of Dresden.

Invasion of Bohemia.

It remained for a few days, and only for a few days, doubtful where the next blow would be struck, and from whom it would proceed. The Austrians had proclaimed so loudly their intention of marching on Berlin, and they were commanded by a general whose character stood so high for daring, that the Prussian citizens trembled for their capital. Their suspense was soon over. On the 23rd June those Prussian corps which stood on the borders of Saxony and Silesia crossed the northern frontier of Bohemia, and on the 26th the rest of the army, (which was on the north eastern frontier of Bohemia), started to unite with them.

The troops thus put in motion consisted of three armies under separate commanders; the whole acting under orders nominally given by the King, and practically emanating from his chief military adviser Lieut.-General Baron von Moltke. The army holding the right of the Prussian front, was the one that had occupied Saxony, it was called the Elbe Army and was commanded (as I before mentioned) by General Herwarth von Bittenfeld. Its line of route was from Dresden through Rumburg towards Munchengratz. Its force was about 40,000 men and 135 guns. (See Plan 1).

The army in the centre, called the 1st Army, was commanded by Prince Frederick Charles, and numbered 81,000 men and 270 guns. It crossed the frontier by two roads, at Seidenberg and Zittau; united at Reichenberg, and then moved on Turnau nearly parallel to the Elbe Army, at about ten miles from it. After reaching the river Iser the Elbe Army and the 1st Army co-operated together, the former always occupying the right flank.

The army on the left, called the 2nd Army, was separated by a wide interval from the centre: it was commanded by the Crown Prince, and contained 100,000 men and 360 guns. The roads by which it entered Bohemia lead from Landshut, Braunau, and Glatz in a nearly westerly direction. It had a more hazardous task to perform than the 1st Army, for it had a greater extent of mountainous country to traverse, and its route lay nearer to the Austrian head-quarters.* There was too a line of railway on the Austrian side, (promising facilities for bringing up troops,) which, if the defiles were guarded, and the columns were checked for a single day might prove fatal to the scheme.

Everything had been carefully and intelligently prepared for the invasion even to the laying down of electric telegraph lines for the different columns to communicate their progress to head-quarters.† But the general feeling of the Prussians was that they were venturing on a path full of danger.

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* As the first army had the advantage of the presence of the "Times" military correspondent, who described its operations in an admirable manner, whilst the movements and encounters of the second army were only made known by brief telegrams and occasional notices, the part which it had to play was not sufficiently appreciated or understood in this country. In Prussia, on the other hand, the first army considered itself underrated, and a pamphlet has been published to vindicate its share in the hardships and glories of the campaign. (See also note B, p. 380).

† Some account of these field telegraph arrangments will be found in the "Times" of 3rd and 7th July, 1866.

The Austrians on the other hand loudly declared their confidence of success. What could the needle gun do against the bayonet as they would use it; and where was the general who could compete with Benedek? There was some little wonder first that the Prussians had been permitted to seize Saxony, and next that they were allowed to decend safely into Bohemia, but the public journals imputed this to a deep laid scheme, and, that the invaders would be surely and thoroughly overthrown, was trustfully predicted by every newspaper at Vienna.*

The actual disposition of the Austrian troops when the invasion took place was as follows. Benedek had six army corps† and two divisions of heavy cavalry under his orders; in addition to which there was the Saxon army, about 20,000 strong, come to fight under the Austrian flag. This army and the first Austrian Corps were at the Iser, the river which flows past Munchengratz; on them it would devolve to check Prince Frederick Charles and General Herwarth. The rest of the Austrian Corps had just been collected on the Upper Elbe and stood as shewn on Plan 2 thus:—6th at Neustadt, the 8th at Jaromirz; the 2nd at Josephstadt, the 4th at Königinhof; and the 10th at Arnau. These five corps therefore stood directly in front of the 2nd Prussian Army, and threatened to meet and overpower it before it was clear of the mountain defiles. (See Plan 2.)

Putting the troops on each side in numbers, it appears that towards the Iser there were about 55,000 Austrians against 120,000 Prussians; whereas on the Upper Elbe there were 160,000 Austrians against 100,000 Prussians; now the Austrians on the river Iser might retire before the superior force of Prussians (if they did it slowly and steadily) without serious disadvantage to their further prospects, but the 2nd Prussian Army must either force its way against the five corps opposed to it, or see the object of the campaign frustrated. If this army were defeated, and driven back, the main strength of the Austrians would be quickly moved towards the Iser, where Prince Frederick Charles would have to accept battle, when out-numbered, or retire out of Bohemia. Any one who could have been aware of all these circumstances would have pronounced that on the whole the chances of success were against the Prussians, and, if they had been defeated here, nobody would have found fault with the passes having been left open to them; superficial writers would probably have approved it, and regarded it as a stratagem to tempt the invaders to their ultimate destruction.

To secure a superiority of numbers at a decisive point is one of the chief objects of military leadership; yet it often happens that the more numerous side is worsted, and a fresh example of such a result was furnished here. In every collision that occurred between the Austrians and the 2nd Army, the final advantage rested with the Prussians. Indeed in every encounter but one, the success was immediate and decisive; in many it was attended with symptoms of panic in the Austrian ranks.

The 2nd Prussian Army consisted of four corps, the 1st, the 5th, the 6th, and the Guards Corps. Of these the 6th had been sent to make a demonstration in a southerly direction,—to divert the Austrians from the true point of

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* See "Times," 14th July, 1866.

† For the composition of the Army Corps on each side see note A, p. 379.

advance;—it was a good deal in rear of the rest; and was also below its full strength; the other three marched with an even front along the three roads above mentioned. The corps on the left flank, the 5th was in the most dangerous place; fortunately it was in the hands of General Steinmetz, a veteran whose military career dates from the campaign of 1813, but whose age does not prevent his being esteemed one of the best generals in the Prussian service. On the 27th June, the 6th Austrian Corps met him at Nachod, and he defeated it: on the 28th he repeated the victory at Skalitz over the remains of the same corps, supported by two brigades of the 2nd Corps; and on the 29th his troops again engaged the advanced guard of the 4th Austrian corps near Jaromirz. Being at the close of these severe encounters much weakened in numbers, the 5th Corps held back, to form the reserve, and its place was taken by the 6th Corps.

The 1st Prussian Corps held the right of the 2nd Army; it met the advanced troops of the Austrian 10th Corps at Trautenau, and at first repulsed them, but later in the day General Gablentz the Austrian Commander brought up the whole of his corps, and the Prussians in turn were driven back beyond Trautenau. This was on the 27th June, the day of the first action fought by Steinmetz. On the 28th General Gablentz was directed to pursue his advantage, supported by part of the 4th Corps, and to move towards his right, to retrieve the injury suffered by the discomfiture of the 6th Corps. But the Prussian Guards Corps, which was marching between the two flanks of the 2nd Army, had moved boldly forwards to prevent this very manœuvre: it met Gablentz at Burgersdorf and Soor (near where Frederick the Great had defeated the Duke of Lorraine in 1745), and robbed him of what few laurels he had won on the previous day.

Further encounters took place on the 29th and 30th, always to the advantage of the Prussians. Königinhof was taken, and a passage over the Elbe secured there. The Austrian attempts to arrest the 2nd Army had ended in failure; and now Benedek learned,—what he might have calculated on sooner or later, but which he spoke of as an unexpected disaster,—viz. that the 1st Austrian Corps and the Saxons had been beaten by Prince Frederick Charles, and that the position of the 1st Prussian Army had become threatening to his left rear. Under these circumstances he gave orders to fall back upon Königgratz.

That Prince Frederick Charles's army should steadily advance, in spite of the Austrian force opposed to it, was (as we have already observed) the natural consequence of their disparity in numbers. There had been encounters before reaching the Iser; and again at the river side, on the 26th and 28th June.* On the 29th a more serious contest took place for the possession of Gitschin or Jicin; a position which Count Clam Gallas, the Austrian General held, with all the forces under his command. The action began in the afternoon, the place was stormed at midnight. Next morning Clam Gallas' troops were hurrying in disorder towards Königgratz; there were no longer any hostile bodies between the 1st and 2nd Prussian Armies; free communication could be established between them; and their junction being thus effected, the first stage of the invasion was completed.

* For particulars, see the "Times" of 3rd July and 6th July; Liebenau, Hünerwasser, Turnau, Podol, and Munchengratz (the last three on the river), were the scenes of action.

Battle of Königgratz.

Besides the losses which the Austrians had suffered in killed and wounded their ranks were weakened by the capture of prisoners to the extraordinary number of 18,000 men, and their artillery was diminished by 24 guns. The infantry was seized with a fear of the needle gun, and the confidence of the army began to be shaken. Their position might be retrieved, it is true, by a single great victory, but even Benedek felt that the moment was inopportune for committing the safety of the empire to the chance of a general action. He recommended to the government that the army should retreat towards Olmutz, but the Emperor's advisers did not give their sanction to the measure.*

It was fully expected by the Prussian staff officers that Benedek would at least retire to the left bank of the Elbe below the fortress of Josefstadt, and it was intended that the army should have a short rest before it made any further advance. The King had now come to take command in person, and his head quarters were at Gitschin. Prince Frederick Charles visited him there on the 2nd July, and quitted it with the understanding that his troops would remain, for one day at least, in their actual quarters. But, on reaching Kamenitz, his own head quarters (see Plan 2), at about half-past four in the afternoon, he received intelligence, gained by reconnoitring parties, that the Austrians were in great force on the right bank of the Elbe, occupying a tract of ground between it and a brook called the Bistritz. Their outposts were holding villages beyond the brook, and were within nine miles of Kamenitz.

It was impossible to judge whether Benedek had taken up this position as preliminary to a violent onslaught on the 1st Army,—in the chance of crushing it before the 2nd Army could arrive on the field,—or whether it was selected with the view of receiving there the Prussian attack. In either case the proper preliminary measures to be taken by Prince Frederick Charles were the same, and they were ordered and carried out in the most prompt and effective manner. The Prince directed the divisions of his own army to take such positions under cover of the ridge facing the Bistritz, and commanding the road towards Sadowa, as would enable them to co-operate effectively if they were attacked, and would likewise facilitate their moving against Benedek's position if events rendered it desirable to do so. Wishing to tempt Benedek to advance upon him, his troops were so skilfully posted that Austrian reconnoitring parties would have failed to discover the dispositions of the force, even if they had detected its presence.

He also showed his aptitude for high command by planning an auxiliary manœuvre.† He sent instructions to the Elbe Army on his right to move upon Nechanitz (a village on the Bistritz), five miles below Sadowa and thence to operate upon the Austrian flank; which would be equally

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* See "Times," 3rd August. The fact is there very positively asserted.

† See however note C, p. 381; a later account attributes all the credit of the arrangements to a different quarter.

practicable whether Benedek crossed the Bistritz at Sadowa, or remained on the defensive behind it.

To the 2nd Army, over whose movements he had no control, Prince Frederick despatched a messenger begging the Crown Prince to send at least one corps against the Austrian right; and to the King's head quarters he sent his own chief of the staff to report upon the whole state of affairs.

The King approved of these measures, and supported them by forwarding a positive order to the Crown Prince to advance,—not merely a single corps, but,—his whole army: at the same time he enjoined Prince Frederick Charles to be cautious about provoking an engagement next morning, lest, if it began early, the co-operation of the 2nd Army might be precariously late.

Thus it was a matter of uncertainty in the Prussian Army on the morning of the 3rd July, whether the battle would be on the near or the far side of the Bistritz. Nor was there any plan of action, beyond the general intention that the 1st Army should bear the brunt, trusting to diversions being made, sooner or later, on each flank. None of the staff had any special acquaintance with the ground, and the enemy's position had not been reconnoitred except by the parties who brought the first news of an army being there. On the other hand it was to be supposed that Benedek had all his forces well in hand,—that he knew the ground,—that he had adapted his plan (whether for attack or defence) to the circumstances of it,—and that he would be able to avail himself of any advantage which the natural features afforded. For the Prussian generals to court, rather than to shun, a battle under such circumstances, was a peculiarly bold resolution.

The divisions of Prince Frederick Charles's Army moved, in the evening and night of the 2nd July, to the places appointed, and waited there till half-past five on the following morning; finding then that there were no indications of an attack from the enemy, they moved nearer to the Bistritz. The Austrian outposts had been withdrawn beyond the brook, and it now appeared doubtful whether anything more than a rear guard remained in position; but as the Prussians approached the stream a heavy artillery fire was opened upon them, and showed that the rising ground beyond was held in great strength.

Benedek had in fact assembled there all his available troops, and they may be reckoned, after due allowance for previous losses, at 180,000 men and 600 guns. Their front was towards the north-west; all the troops faced the Bistritz; none were put in line towards the north-east, in which direction the Crown Prince's Army lay; but the length of front was so short compared with the number of men on the ground, that plenty could be spared to fight on the flanks without any risk of weakening the centre.

The ground was of an irregular undulating character, ridges and valleys alternating with one another, and presenting no marked features to catch the eye, except that to a spectator in the Prussian 1st Army, a knoll near Chlum appeared as the highest point of the line. A good straight road leading to Königgratz crossed the Bistritz at Sadowa and passed near the knoll. Two miles above Sadowa the Bistritz made a sudden bend, the line of its course tending to the north-west instead of the north-east; and opposite to this bend, near Horenowes, was the Austrian right flank, thence the line ran parallel to the Bistritz for about six miles; as far as Prim, with out-

posts occupying the village of Nechanitz. There were bridges at several places over the Bistritz, but it was not easily passable elsewhere, and the ground near it was swampy. (See Plan 3).

The most important considerations bearing on the Prussian arrangements relate (1) to the distances which the various corps of the Crown Prince's Army would have to march before they could render any active help to Prince Frederick Charles; and (2) to the relative numbers which might be brought into action, on the Prussian and Austrian side, before any of those corps arrived.

The nearest troops of the Crown Prince's Army were one division (half the corps) of the guard at Königinhof; the other division was at Rettendorf, two and a half miles further. From Königinhof to Horenowes is nine miles in a straight line, and upwards of ten by road. A single regiment might march this distance in three and a half hours; for a column of 12,000 men, with a cavalry and artillery (which would occupy three miles length on the road) an additional hour must be allowed. Some time must also be spent in examining the ground and preparing for action when the enemy's position became visible, so that five hours would probably elapse, after the nearest division began its march, before it could take any serious share in the day's work. Of the other corps under the Crown Prince, the 6th was near Gradlitz, and had about the same length of march before it as the Guard Corps, but would probably not get orders soon enough to start so early. The 1st Corps, at Prausnitz and Arnau was further off. The 5th Corps was to act as a reserve, not entering into action without special orders.

The staff officer sent with Prince Frederick Charles's message reached the Crown Prince at one in the morning, and rejoined with his report at four; consequently there was no doubt about the application for assistance having arrived.* The King's orders would necessarily be later, for they were not despatched from Gitschin till midnight; everything considered, it would appear that a division might be on the ground, possibly by nine,—reasonably by ten o'clock, and further troops in regular succession.

Turn now to the Austrian side. It is to be noted that in July it becomes light between three and four, so that if Benedek had it in view to throw the weight of his force upon the army nearest to him, and seized the earliest dawn for opening the battle, there would be several hours during which he would enjoy all the advantage that numbers could give him: Prince Frederick Charles had only 75,000 men available for immediate use, and 35,000 sent round by Nechanitz; Benedek's total force was 180,000.

You will observe then that the Battle of Königgratz was begun under exceptional circumstances, and which may be thus recapitulated. The Prussian armies, which entered Bohemia by widely separated routes, had effected a junction with one another, so far as free direct communication went, but were not yet sufficiently concentrated to ensure their co-operation against a very sudden attack. The Prussian staff had calculated, not unreasonably, that Benedek would not offer battle on that side of the Elbe; finding him unexpectedly posted in an advanced and threatening position they boldly prepared to fight, in spite of the risk of placing part of their army in a hazardous position.

* More accurate information about the co-operation of the 2nd Army will be found in note C; p. 381.

Now we may proceed to the actual contest. The 1st Prussian Army consisted of the three corps, the 2nd, 3rd, and 4th, each corps having two divisions. The 2nd Corps was opposite the villages below Sadowa, the 4th was on its left; one of its divisions (the 8th) prepared to cross the Bistritz at Sadowa; the other, (7th,) was sent against the village of Benatek. The 3rd Corps was held in reserve. Whilst these dispositions were being made a heavy artillery fire was being exchanged.

When this fire, which had begun before seven, had lasted about two hours, the King, who had arrived on the field, ordered the 8th Division and the 2nd Corps to cross over the brook, and by 9 o'clock they were fully engaged. Towards ten the head of the Elbe Army, under General von Herwarth, reached Nechanitz, effected a passage there, and proceeded to execute the manœuvre entrusted to it, by sending a division round the Austrian's extreme left. As however this was an operation requiring some time another division was launched against the front, so as to support the left of the 2nd Corps and establish a feeling with the 1st Army generally. The remaining division, of which the Elbe Army consisted, was for the present held in reserve.

From nine o'clock till noon the combat was maintained by the 2nd and 4th Corps, from Benatek to Mokrowous, with a courage and an endurance deserving the highest praise. They tenaciously held the villages and ground immediately beyond the brook, and if they could not carry the slopes of the hills it was because they were fighting on widely unequal terms. The Austrian infantry were more numerous, and the Austrian artillery, turning to proper account the advantages of a selected position, had cut down trees and made preparations for developing to the utmost the effect of their guns. It would have seemed a reasonable result, and have implied no discredit to the Prussian soldiers, if they had been hurled back across the Bistritz, as the only reward of their venturesome operations.

The hour at which a part of the Crown Prince's Army might have been expected to make its appearance felt had now long past, and no signs of its approach were visible. The Prussian staff began to feel uneasy, not that they doubted of ultimate victory for help would surely arrive before the day was over, but they began to fear that their own unequal struggle could not be much longer maintained, and if they had been able to withdraw the divisions that were now under fire, without too much risk of disorder, they would probably have done so. The troops being too deeply engaged to render such a measure practicable, the only alternative was to reinforce them, and about 12 o'clock the 3rd Corps was ordered to take part in the battle.

Soon afterwards it was observed by the eager watchers of the King's staff that the artillery fire from the Austrian right was aimed in a new direction. The fact was cheering, but some doubt remained whether it was really caused by the arrival of the Crown Prince or whether the 7th Division, which was fighting in front of Benatek, had got too far to the left. It was not till two o'clock that the uncertainty was fully removed. Then massive columns of infantry were seen crowning the ridges; an evident disturbance was produced in the enemy's arrangements, and the King's painful anxiety was turned into confidence and joy.

The 1st Division of the Guard (from Königinhof) was the first to arrive

on the ground. Their march had been impeded by heavy rain and the consequent bad state of the roads, and took six hours instead of five; it was about twelve o'clock when the artillery were near enough to open fire and cover the infantry's advance. Soon afterwards part of the 6th Corps reached the ground; it came up far to the Guards' left, its own left being near the Elbe. The remainder of the corps, except one brigade left to watch the fortress of Josefstadt, filled when it arrived, the vacant space. The 2nd Division of the Guard followed the 1st Division at an interval of nearly two hours, and bending to the right, attacked Lipa and Chlum. The 1st Corps gave support to the 7th Division of the 4th Corps, and to this division of the guard. The 5th Corps occupied its normal place as a general reserve. Thus the whole of the Crown Prince's army was on the ground in time to share more or less in the events of the day.

On the opposite flank, at five or six miles distance, General Herwarth was pushing on with steady skill and good courage, and had fully attained his object of turning the Austrian left. Between three and four o'clock, when the guard was close upon the Sadowa road at Chlum and Rosberitz, one of Herwarth's divisions was near Charbusitz, whilst the other two were in occupation of Prim and Problus. The Austrian army was now pressed in front, pierced in the centre, assailed on both sides, and with its very line of retreat endangered. About three o'clock the King's staff observed that the Austrian artillery fire had generally slackened, and soon there came a recommendation from the front that the reserve cavalry should be sent forward. At half-past three the King put himself at their head and rode triumphantly through his victorious troops. Well might they greet him with cheers, and well might his heart be proud, for Prussia had won within the last few hours a new position in the world.

Benedek's short published despatch, dated the 4th July,* attributed the defeat solely to the Prussians succeeding, under cover of the smoke and mist, in establishing themselves unobserved at Chlum, where they were in rear of part of his line. Nothing could give a more false impression of the day's proceedings. If the despatch in question really emanated from him he must have been, even on the following day, ignorant of the general bearing of the battle; such a misapprehension is not consistent with the keen insight which is an indispensable quality for a good Commander-in-Chief.

Advance of the Prussians into Austria.

The interest of the campaign, and indeed of the whole war, culminated with the battle of Königgratz. The trophies were 174 guns, 11 standards, and 22,000 unwounded prisoners. The results were that Austria sued for peace. An armistice was applied for and refused. Pending the negotiations the Prussians advanced towards Vienna.

On the 5th July, the day next but one after the victory, the forces crossed the Elbe in the neighbourhood of Pardubitz. On moving thence the three armies diverged from one another; the Crown Prince, still on the left, marched towards Olmutz, in which direction the main body of Austrians

* In the "Times" of 6th July.

had retired; Prince Frederick Charles marched towards Brunn, and General Herwarth, again on the right, moved southerly by Iglau and Znaym. As the Austrians withdrew their forces from Olmutz, and concentrated them at Vienna and Presburg, the Prussians also brought their corps nearer together, leaving a division to watch the garrison of Olmutz, and by the 19th July their outposts were within 15 miles of the Danube. (See Plan 1).

Their progress had been unopposed, but twice they had come in contact with the retiring Austrians. At Tischnowitz, before reaching Brunn, there was a cavalry skirmish, described with great spirit in the columns of the "Times" and interesting in its details as shewing how the Prussian cavalry, as well as the infantry, astonished their adversaries by the use of their breech-loading fire-arms. At Tobitschau about twelve miles south of Olmutz, part of the 1st Prussian Corps, principally composed of cavalry, fell unexpectedly upon the head of an Austrian column marching from Olmutz towards Presburg, forced it out of its intended line of route, and succeeded in capturing 16 guns.

Benedek himself was present on this occasion. Since the battle of Königgratz he had been at Olmutz, which is a fortified place of considerable importance, with an intrenched camp capable of sheltering a large army; but was then without any store of provisions sufficient for so great a number of men as had unexpectedly been collected there. Part of the troops were sent to Vienna by railway, but the Prussians soon reached the line and intercepted any further transport by that means. The rest had to march by road. After the affair at Tobitschau the nearest route was barred to them, Benedek had to lead the 1st and 8th Corps across the Carpathian mountains, into the valley of the Waag, and thence to Presburg.

The Archduke Albert had now arrived from Italy to supersede Benedek in the command, and had brought with him the principal part of the army which had won the victory of Custozza. Negotiations were going on, but the results were still doubtful, and it became an interesting speculation how the Prussians would grapple with the next difficulty before them, viz. the passage of the Danube. Napoleon had met with it twice in his career. The first time, in 1805, he gained possession of the bridge by an act of trickery,* the second time, 1809, he had to construct military bridges, and failed in one attempt to effect a passage. The villages of Aspern and Wagram, within a few miles of Vienna, recall the bloody struggles which the passage of the Danube then cost the French army.

An armistice was arranged soon enough to prevent this military spectacle; the suspension of hostilities was to commence on the 22nd July at noon, and it happened, as another parallel to the campaign of 1809, that when the appointed hour came a hot contest was actually going on. Although this contest came too late to be of any value on one side or the other, and the blood that was spilt was, unfortunately, uselessly sacrificed, it was very near being attended with a striking success; and being generally well illustrative

* Murat and Lannes, according to the story, got a footing on the bridge, which was prepared for demolition, by asserting that an armistice was arranged; and then rapidly secured it so as to prevent the mines from being sprung. The circumstances, so far as I have found them described, betray such an inexcusable disregard of ordinary precautions that the Austrians fully deserved the consequences.

of the mode in which the Prussians and Austrians respectively fought, it deserves some little description here.

Battle of Blumenau.

Part of the 1st Prussian Army, the 8th Division, in marching from Brunn towards Vienna, had been thrown over to the east side of the river March, and moved down the road leading from Goding to Presburg. At Marchegg, the 7th Division, and another division formed of cavalry, were united to it, the whole being commanded by General Fransecky, who led the 7th Division throughout the battle of Königgratz. On the 21st July this force was near the village of Bisternitz. The Quarter-Master General of the 1st Army had been reconnoitring that afternoon, and found that the Austrians held the ground about Blumenau (between Bisternitz and Presburg) in some force. As Presburg would be an important place to obtain for further operations on the Danube, the Quarter-Master General thought it desirable to pave the way by dislodging the Austrians from Blumenau, and sent to Prince Frederick Charles to request permission to do so. The Prince readily gave his sanction to the scheme. The messenger returned to Bisternitz at dawn on the 22nd, and General Fransecky forthwith made dispositions for the attack. He proposed not only to carry the position, but to effect it in such a manner that the whole defending force should be captured.

With this view he sent a body of 5000 men under General Bose round by the Gamsenberg to gain a point some distance in rear of the Austrians, and cut off their retreat, whilst he attacked in front. The village of Blumenau stands among the spurs of the Carpathian mountains, with thick, almost impassable woods round it, and but few roads. It presented great facilities for defence, and four Austrian brigades were near enough to contest it; but the nature of the ground was favourable for concealing General Bose's flank march.

The action began as usual by an exchange of artillery, in which forty Austrian and thirty-six Prussian guns took part. At half-past eight an officer came to announce that an armistice was to commence at midday, but Fransecky feared that if he left off fighting General Bose might be captured before the hour for ceasing hostilities had struck: the action therefore continued, and the infantry were brought into play.

Between eleven and twelve a message was delivered from General Bose to report that the enemy's retreat was cut off and that the front attack might be pushed hard. He had, in fact, after some fighting, planted his brigade right across the road between Blumenau and Presburg, and as there was no other road by which the artillery could have marched, every gun would probably have fallen into his hands. It was even doubtful whether the infantry could have escaped by a rough country lane just fit for men on foot. Fransecky ordered a general advance, but he was unable to grasp the success so nearly within his reach, for in a few minutes an officer came out of the Austrian lines with a flag of truce, and the firing on both sides immediately ceased. The Austrians in the front line were totally ignorant of the danger to their rear, and of the escape that they had had. It was not until they had seen General Bose's force with their own eyes that they could believe how thoroughly their retreat was cut off.

Situation of the Austrians at the close of the Campaign.

Before the truce, which was at first fixed for five days only, had expired, the Austrians had evacuated Presburg, and assembled their whole forces on the south bank of the Danube. This amounted to an avowal that they could not venture to remain in front of the Prussians without such a protection as the river afforded. Perhaps it was the wisest, and at any rate it was the most prudent thing they could do, for there is no military operation more hazardous and difficult than to cross such a stream as the Danube is, in that part of its course, in face of a watchful army. The courage and self-confidence of the Austrian infantry had been so much shaken, and the issues of all the combats had been so invariably against them, that there is nothing to lead one to suppose the fortune of war would have suddenly turned in their favour.

Otherwise,—had the Austrians been able to meet the Prussians on anything like equal terms, they would have forfeited, by clinging to the opposite bank of the Danube, the best chance of re-establishing themselves in Moravia by a single blow. With the river between them and the Prussians they could only act defensively. If the Prussians attacked them they might succeed in repelling the attack with loss; but they could do no more. Had they occupied a line facing the west, with the left flank touching the Danube they would have been in a position offering great advantages for the offensive, whilst it combined many of the requirements of a good defensive position.

Thus placed they would have had the river March to protect their front, and the Carpathian mountains to hinder any rapid pursuit in case of retreat. Hungary, which was now their main resource would have been effectually covered, and the bridge at Presburg would have secured their junction with the troops defending Vienna. Looking at it from the offensive point of view they would have been ready to improve any opportunity that might occur by falling upon the Prussians where they stood, or by threatening their flank more to the rear.

Nothing also would have more hampered and checked the Prussian attempts on Vienna than the presence of an Austrian army along the river March. It would have prevented a large part of the army from being employed in forcing the passage of the Danube, and it would have deterred them from establishing one portion of their army on the right hand bank unless it had most ample means of communicating with the other. In fact the Prussians would have been obliged to force this position as a preliminary to attempting Vienna, and in disposing their army to do so they would have had to change their front to the left. The roads by which they communicated with Prussia, or in other words their lines of communication, would then be on their flank instead of in their rear, and in case of a defeat they might be altogether cut off from their supplies. There can, I think, be no doubt, that in a strategical point of view, the line of country between the river March and the Carpathian mountains should have been occupied and held by the main body of the Austrian army*; but the

* This opinion is also held by the author of the "Operations of War," who brings forward most of the points above-mentioned in the article which appeared in Blackwood's Magazine for August,

disordered state of the whole force, and the certainty that the Prussians would lose no time in attempting to drive them out of it, are quite sufficient to justify the other measure. Usually it is considered a great point gained in military operations to place your adversary in such a predicament that he must fight, whilst you can choose the scene of action. It is a sad state for a great army to be reduced to when the avoidance of the enemy, and a shelter behind impassable obstacles, take precedence of all other motives. This was the state of the Austrian army at the end of the Bohemian Campaign.

Campaign on the river Maine.

We now come to the other scene of war in Germany, where those Prussian troops which I mentioned at the beginning of the narrative as having overrun Hanover and Electoral Hesse, allied with some small contingents from the North German States, had to oppose forces brought into the field by the Austrian allies. These consisted of the 7th and 8th Corps of the army which was nominally under control of the German Diet, and was formed by contingents from all states in the German Confederation. The 7th Corps was contributed by Bavaria. The 8th Corps was made up by joint contingents from Wurtemberg, Baden, Hesse Darmstadt, and Nassau. To these must be added the Hessian troops who had escaped when the Prussians entered their territory.

The Prussian troops consisted of three divisions, amounting to 47,000 men and 90 guns, united under the orders of General Vogel von Falkenstein. The strength of the Bavarians was about 44,000 and 144 guns: that of the 8th Corps about 47,000 and 144 guns: the two together would therefore have been nearly double the number of the Prussians, and with a vast preponderance of artillery; but being under separate commands, with their present head-quarters at some distance from one another, it was possible for Falkenstein to encounter them separately, and to delay or prevent their junction.

The 8th Corps, under Prince Alexander of Hesse, assembled round Friedberg, (16 miles north of Frankfort); the Bavarians, under Prince Charles of Bavaria had their head-quarters originally at Bamberg, but receiving an application to move northwards, with the view of giving assistance to the Hanoverian army, they left Bamberg, and at the end of June their head-quarters were at Meiningen. (See Plan 1).

The Hanoverian army, taken by surprise when the Prussians entered the kingdom, and unable to make a stand against them, had retreated to Gottingen, at the southernmost point of the kingdom, about 60 miles from the nearest part of Bavaria. They marched thence on the 20th June, three days after the occupation of Hanover. By the 24th they were at Gr. Gottern, 50 miles from the Bavarian boundary, and if they had proceeded

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1866. The position had suggested itself to me as an advantageous one, but I should not have insisted strongly upon it if the idea had not been supported by such excellent authority. I may take the opportunity of adding that the Austrians, if they had been less disorganized by the battle of Königgratz, might previously have found a position, well calculated for checking the Prussian advance, in the mountains between Bohemia and Moravia.—See Rüstow's History, p. 411.

firmly and rapidly they might have attained their object; but fearing that there was a Prussian force in their front they hesitated, and this hesitation led to the accomplishment of what they feared. When they actually were cut off they offered to treat; then they attempted to break their way through, and finally they laid down their arms at Langensalza.

The Hanoverian army being deprived of participation in the war, the Bavarians turned their attention to effecting a junction with the 8th Corps, (still round Friedberg), and on the 2nd July they began to move in that direction. This, however, it was clearly the object of Falkenstein to prevent. After the surrender of the Hanoverians he had been obliged to remain a few days at Eisenach whilst he organized the forces which had been collected from so many quarters to form his army. Having done so he marched from Eisenach towards Fulda on the day that the Bavarians were tending towards the same place.

The outposts soon came into collision, and on the 3rd and 4th of July, (the date of the battle of Königgratz,) there were several encounters in the neighbourhood of Dermbach, so much to the disadvantage of the Bavarians that they fell back in a south-easterly direction towards the river Saale, with the view of seeking a junction with the 8th Corps in some more convenient quarter.

Successful in the first step, Falkenstein marched on towards Hanau, expecting to meet the 8th Corps in that neighbourhood, but hearing that Prince Alexander had withdrawn his right wing and judging from general intelligence that the Bavarians were still the more dangerous enemy of the two, he altered his direction and marched rapidly upon the Saale.

The Bavarians held Kissingen and other points on the river; their position was strong, but their forces were scattered and badly handled. Although they had a superiority of numbers within reach of the several scenes of action, the Prussians were more numerous at the fighting points, and the Bavarians dislodged from the Saale fell back to the Maine. Falkenstein followed them to the neighbourhood of Schweinfurt, but then made a sudden change of plan, and turning his back upon them in an extraordinary manner, retraced his steps to the Saale.*

Frankfort was henceforth his goal. The vicinity of the city was held by the 8th Corps, but in this ill-starred body confusion reigned supreme, and the only opposition made to his approach was offered by isolated detachments of the corps. The contingent of Hesse-Darmstadt, full of courage, but unskillfully led, threw themselves in his way at Laufach. That point carried a force mainly consisting of 15,000 Austrians barred his passage by posting themselves in Aschaffenburg. As this town was still surrounded by an old wall it might have been a troublesome impediment, but it was soon in the Prussians' hands. In the confusion of retreating out of the town many prisoners were taken; a part of the Austrian soldiers made indeed no attempt to get out; there happened to be two battalions of an Italian regiment within the walls, and these, taking the opportunity of getting free from the Austrian service, allowed themselves to be captured without striking a blow.

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* This change is attributed by a correspondent of the "Kölnische Zeitung" to secret negotiations.

This was the last action fought to save from Prussian profanation the seat of the German Diet. Prince Alexander once more retreated, Falkenstein pressed on, and on the night of the 16th July, Frankfort was no longer a free city.

Here the Prussian army enjoyed four days repose, during which it received some reinforcements from North German States. A change also took place in the command. Falkenstein was removed on appointment as Governor of Bohemia; Manteuffel, one of the divisional commanders succeeded him.

On the 21st of July the three divisions again marched forth. The 8th Corps on quitting Frankfort, had gone towards Wurzburg, where the Bavarians had established themselves since their discomforture at Kissingen, and Manteuffel followed their steps. On the 23rd and 24th there were actions fought on and near the banks of the Tauber, at Bischofsheim, and other places, of which it would be vain to attempt any concise account. Suffice it to say, that on the 26th July Prince Alexander, always retreating, vacated the left bank of the Maine, and on the next day the Prussian field guns were cannonading Wurzburg. Then the truce, which had been made with Austria on the 22nd, was extended to the belligerents here, and in a few days after the 7th and 8th Corps had separated for their own homes.

The Prussian operations on the Maine will always be thrown into the background by the greater magnitude and brilliance of those in Bohemia; the newspapers in this country scarcely noticed them, and my account is derived from German sources. They deserve attention from a military point of view as a good example of what an active general may achieve against a divided enemy of double his own strength, and their result was important by securing to Prussia a complete and incontestable superiority in all North Germany.

Review.

Having now completed a general outline of the operations of the war, it remains for us to enquire what enabled the Prussians to achieve the wonderful and rapid success which attended them.

To men whose duty it is to study military art this is the more important branch of the subject. From time to time new kinds of weapons are invented, and changes of weapons causes changes in the mode of drawing up and manœuvring troops. Many of the discoveries and improvements of peaceful life, such as new modes of locomotion and communication, also find their way into military service, and most wars offer, in consequence, some points of difference from previous wars; independently of each war being a fresh example of those unalterable principles which are common to war in every age of the world's history.

Of all the improvements that have been made in military weapons I should think none ever fulfilled its mission with such brilliant results as the breech-loading needle gun. It is the object of all such improvements to make a soldier more than a match for any other soldier not similarly equipped. The purpose of sucessively changing from bows and arrows to fire-arms;—from guns with flint locks to percussion locks,—from muskets to rifles,—and from muzzle-loaders to breech-loaders, has been to increase every man's power of disabling his adversary by shooting further, or with more accuracy, or

with more rapidity. The influence which alterations of this kind exercise is sometimes so small that it escapes general attention, or becomes a matter of dispute among writers. In this instance there is no doubt that the Prussian gun did make their infantry fire far more deadly than that of the enemy, and that partly in this direct manner, partly in an indirect manner, it had a very powerful influence on the Bohemian campaign.

The first few combats on that scene sufficed to establish its superiority. It appeared that the needle breech-loader could, as anticipated, be fired nearly three times whilst the muzzle-loader could be fired once; and that when bodies of infantry were at close quarters, firing rapidly without accurate aim being needful, one Prussian soldier was, for the moment, on a par with more than one of his opponents. The remedy which Benedek had recommended,—the use of the bayonet,—proved (as might have been expected) ill-judged and ineffective, and demoralization soon began to show itself in the Austrian ranks. After the battle of Königgratz, it had reached such a point that during the march from Olmutz, a mere verbal alarm of the Prussians being at hand caused the infantry to take to flight, many throwing down their arms, under Benedek's own eye. Indignant at such conduct he threatened to have every man shot who had thus discarded his weapon; "but," says the military correspondent of the "Times,"* (who was present on the occasion) "the number of victims would have borne a fair proportion to the executioners." A gun that could be the means, directly or indirectly, of producing such an unreadiness to fight, may fairly be said to have realized the most sanguine hopes of its introducer.

The Prussians had not only taken the lead in adopting a quick firing gun, but they had adapted the formation and manœuvres of their infantry to it, and they had foreseen with a remarkable precision what an enemy exposed to their fire would have recourse to. An official book of instructions for the army,† printed at Berlin in 1861 (six years ago), says that an adversary armed with such a rifle as the Minié, "when engaged with the needle gun will seek safety in the bayonet-encounter." Benedek's address to his army on taking command of it contains the following passage. "The enemy have for some time vaunted the excellence of their fire-arms, but, soldiers, I do not think that will be of much avail to them. We will give them no time, but we will attack them with the bayonet and with crossed muskets. When, with God's help we shall have beaten our enemies and compelled them to retreat, we will pursue them without intermission."‡ I think it is seldom that a prediction of any kind has been fulfilled with such literal accuracy as in this instance.

With a gun possessing certain peculiar advantages, with a system of tactics adapted to the gun, and an enemy taking the very course which they were best prepared to counteract, there can be little doubt that the Prussians would have been victorious, even if the two armies had been equally matched in other respects, but if we were to assume without further enquiry that all their success was due to this one cause, we should not do justice to their proficiency in the art of war; and if we were to attribute the disorder in the

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* 4th Aug., 1866.

† "Allerhöchste Verordnungen über die grösseren Truppenübungen."

‡ See "Times," 22nd June, 1866.

Austrian ranks solely to the needle gun, we should rate too highly the value of the weapon, whilst we neglected certain very important features of national character and political conditions which contributed to it. These two points then,—the comparative proficiency in the art of war, and the national elements on both sides, claim our next attention.

The art of war in its full signification is not confined to the leadership of an army in the field, it includes also the organization which fits it for taking the field, including all the arrangements for supplying the combatants with food, medical attendance, ammunition, and other wants. It is, however, only within the most modern periods that proper attention has been paid to those branches,—the non-combatant departments of the army. Formerly all kinds of supplies and transport were arranged by a contract system kept up during hostilities only. But it depends on the condition of an army in the non-combatant as well as the combatant branches whether it is at once fit to "go anywhere and do anything," (as the Duke of Wellington said of his army at the end of the Peninsula war), or whether it has to pass through a stage of helpless inefficiency, frequently attended by hardship and disaster, before it is brought into working order.

In our own country, up to the time of the Crimean war, most of the non-combatant branches were totally neglected. Continental nations have been obliged to pay more attention to their military system, and both Prussia and Austria had armies so well appointed in all branches that no advantage could have been predicted to either on that score. The extraordinary course of events prevented any good comparison between their capabilities under this head, because the circumstances quickly became so widely different, but the merits of the Prussian army shone clearly forth. The men fought bravely, behaved soberly, and suffered the trials of the campaign cheerfully. The officers of every grade, from the highest to the most subordinate, fulfilled their duties with a surprising excellence. There was no want of decision, nor of co-operation; nor was there any blundering detected. Of the non-combatant departments no complaints were made, though doubtless some of them were overworked, and unequal to the heavy and immediate strain on their resources. It would be captious and unfair to make much of short comings due only to want of strength and not to want of organization. It must be acknowledged, on the whole, that the army as an organized and well trained body reflected the highest credit on the government.

Apart from the military style and discipline, there was an unusually high tone of feeling in the Prussian army. There was patient trustfulness without arrogance. The men were brothers, and their country was the Fatherland. They had a definite national ambition. Whatever the politics of the government might be, their own earnest wish was unity and freedom for the whole German race. The system also which obliged all stations of life to undergo military service, infused in the ranks a high degree of intelligence and education.

Now, compare this unity of race, and this community of feeling, with the incongruous assemblage of the Austrian army.

Austria is an empire which might be taken as a representative example of that system under which countries were the appanage of thrones and dynasties, and nations were united by bequest or by hereditary succession

under the same Crown, without any regard to similiarity between them. The system has frequently acted well, and produced a unity which would not have been attained by other means. We should remember that we owe to it the cessation of strife between Scotland and England, and without it France and Spain might have continued to be, like Germany, and like Italy a few years ago, subdivided into independent states; but it has proved otherwise when the nations united by a despotic rule are different in religion, language, and habit, without any common bond of interest between them.

There have been collected under the sceptre of the House of Austria, an unusual number of countries and races which have neither amalgamated together, nor rested contentedly under the central government, but from these Austria has been obliged to draw the principal number of her recruits. Out of every 100 soldiers only 26 are of true German origin; 20 are Czechians, 20 Ruthinians, 11 Italian; the remaining 33 are made up of Hungarians, Poles, Croats, Servians, and others.* Ten languages are spoken among them. How Hungary is in a state of continual disaffection, and how the Italian provinces were retained only by force of arms, I need not say. We too have the misfortune of owning a disaffected country, but Irish soldiers soon forget the sentimental grievances learned at home, and readily devote their lives to support the honour of the British flag. Among the Austrian subjects the feeling is far deeper, and betrays itself in every war. In 1848, 15,000 Lombard soldiers of Radetzky's army mutinied against their officers. In 1859, at Magenta, one battalion surrendered in a body to the French, and eight battalions would not fight; one of the men bayoneted an officer who tried to rally them. In this campaign of 1866 the evil went still further, and the number of prisoners, many of whom were undoubtedly willing prisoners, was astonishing.

When the captured men were released at the end of the war there were found to be only about 577 Prussian officers and men to be exchanged for 48,559 Austrians. 577 for 48,559—83 Austrians for every single Prussian.†

It is therefore abundantly clear that political disaffection was deeply concerned in the Austrian overthrow, and that the demoralization in the ranks was not solely due to the needle gun. If corroboration were wanting we should find by turning to the campaign on the river Maine that though the Prussians there were equally well led, equally victorious in every encounter, and equally armed with the needle gun, there was never any great preponderance of loss on the enemy's side. Further, it is worth observing that the Austrians, as a military nation, do not excel in infantry fire. In the wars with Frederick the Great, when battles were often won from them by inferior numbers of Prussians, the success was considered to be partly due to the superior steadiness and precision of the latter in the use of musketry. Frederick himself makes an observation, in his memoirs, to the effect that if he could pour two or three volleys into an Austrian battalion

* This is the per centage given in an account of the Austrian Army by Capt. Petrie, 14th Regt. (then on the Topographical Staff) a few years ago. See Journal of the United Service Institution, 1861. The changes since that time have not been important enough to affect the point of the argument.

† See "Times;" leading article, 5th Sept., 1866; also 3rd Sept., 1866.

the result was safe. In the Italian campaign of 1859 the Austrians suffered a series of defeats; and on particular occasions when they had superior numbers on the spot they effected nothing. This also was attributed to a want of quickness as compared with the French. To use an Austrian officer's own expression, in a conversation with myself, they stood up to be shot at.

There seem, then, to have been three influences at work to produce that disorder in the Austrian ranks which soon made it hopeless to take them into action. The needle gun, political disaffection, combined with a want of national unity, and a certain inaptness for infantry firing. Of these the needle gun may fairly be put first, not only because of its importance, but because it may have been the means of bringing into activity the rebellious discontent. Had there been no needle gun in the case the first of the encounters might have been in favour of the Austrians, and so long as they had victory on their side the men would probably have remained true to their colours; a fortunate soldier is pleased with himself and contented with his position; it is reverse and privation which excite disloyal feelings, and relax the ties of discipline.

Would, however, the Austrians have escaped ultimate defeat if there had been no needle gun against them? This of course is a matter of speculation. They certainly ought to have been able to drive the Crown Prince's invading force back into Silesia, because by the relative positions of the various army corps on both sides the Austrians had a superior number ready to oppose to him. Any further inferences, can only be drawn from comparing the leadership and tactical proficiency on both sides. The comparison is not favourable to the Austrians. The chief foundations for this statement may be shortly laid down.

The Austrians neglected proper precautions for defending the passes into Bohemia, and when the enemy was approaching their positions the Corps Commanders did not generally execute satisfactorily the orders which Benedek transmitted to them. It was also clear on one or two occasions (especially at Tobitschau and Blumenau) by the facility with which the Austrians were surprised and outflanked, that either there was a want of system for learning the enemy's movements, or that the proper duties were shamefully neglected.

The Prussians neglected nothing, whilst they ventured much. Their mode of invasion exposed the armies to a serious risk until their junction was effected, but this was indispensable. They could not throw so large a force into Bohemia in any other manner, on account of their being but few good roads over the intervening mountains. The invention of this plan was generally attributed to Von Moltke, the chief of the King's Staff; but there was no originality in it, for in Frederick the Great's time separate columns of Prussian troops had repeatedly crossed the mountains by the same, or nearly the same, routes, and had united at some preconcerted point in the basin of Bohemia. What is most to be admired in the Prussian strategy is the exactness with which the plans were carried into effect throughout the war. Rarely has so large a force executed extensive operations with such remarkable absence of mistakes and failures, within the first ew days after hostilities being declared. And in their tactical dispositions or giving battle they showed a peculiar readiness for planning and making

attacks on the enemy's flank. This manœuvre is one of the most effective that can be performed if it be executed with precision; but, as the force in front is necessarily weakened, flank attacks can seldom be ventured upon except when there is a superiority of numbers on the assailant's side. It was however part of the Prussian system to rely on the needle gun giving them such an advantage as to enable them, when numbers were equal, to resort to this operation, thus developing to the utmost the application of their peculiar weapon.*

How could an army have fulfilled its mission better? It is the highest testimony to the Prussian training and organization, that an army hastily raised to the full establishment—with the Danish affairs of 1848 and 1864 as their only experience of war—should have acted like veterans formed by years of service in the field.

Yet of this army Benedek had spoken in the following terms, when he issued the address before mentioned. "We are now faced," he said, "by inimical forces composed partly of troops of the line and partly of Landwehr. The first comprises young men not accustomed to privations and fatigues, and who have never yet made an important campaign; the latter is composed of doubtful and dissatisfied elements, which, rather than fight against us, would prefer the downfall of their government. In consequence of a long course of years of peace the enemy does not possess a single general who has had the opportunity of learning his duties on the field of battle. Veterans of the Mincio and Palestro, I hope that with tried leaders you will not allow the slightest advantage to such an adversary."

It must be confessed that this language was ill-chosen and arrogant, and his use of such terms must be regretted by those who are aware of his previous achievements, or who have personally learned his private worth. Its only excuse must be that it was intended to give confidence to his men and to accord with the tone of the public press.

Feldzeugmeister Ludwig von Benedek had been called to the supreme command by the Emperor, with the general approval of the army, and to the perfect satisfaction of the Austrian people, he had distinguished himself at the head of an army corp in the Italian campaign of 1859; and was indeed the only one of the corps commanders who had come with credit out of the contest As an independent commander-in-chief he had indeed had no experience, but every one felt sure that he would not repeat the errors of hesitation and inactivity which had so often been the reproach of Austrian leaders. So far, but no further, he justified popular expectations.

It is not indeed to be supposed that he is responsible for the want of preparation which made the Austrians behindhand in taking the offensive; nor for the unguarded state of the Bohemian passes. The Emperor's military advisers, and the War Department at Vienna, are chargeable with these omissions. The neglect caused a sacrifice of advantages which the Austrians could ill spare, but left them still with the chances of success favourable to their side. The time when Benedek's generalship came first into play was after the defeat which all his advanced corps suffered at the

* This is clearly laid down in the book of instructions already quoted.

end of June. If he then recommended a retreat, and proposed not to offer battle until circumstances were more favourable for it, he is not answerable for the consequence of his advice being disregarded, and his proposition over-ruled. It is however to be presumed that the choice of a field of battle, anywhere near his actual position, was left to his unfettered judgment, and in this choice he is fairly open to criticism.*

You will remember that he drew up his army facing the Bistritz brook with outposts resting on the stream; his right was near Horenowes, his left was at Prim. He made no special dispositions for securing his flanks, but he had nearly double the number of men necessary for holding the length of front he occupied.

You will also remember that the 1st Army and the Elbe Army were straight before him, whilst the 2nd or Crown Prince's army, was in such a position that if it took any part in the battle it must fall upon the right flank.

Had Benedek placed the Elbe between himself and the Prussians, or had he taken up a line between Königgratz and Chlumetz as suggested by an eminent German critic,† he would have a good defensive position, and have been secure for a day or two against a combined attack. Had he vigorously assailed the 1st Army he might possibly have defeated it before the Crown Prince came up. Either of these measures would have been reasonable. In placing himself between the river and the Prussians, and waiting passively there, he adopted a half measure without anything to recommend it. His expectant attitude on the morning of the battle showed that his intention was to act defensively, and this being the case it is incomprehensible how he should so much have neglected the right flank. It is bad for an army to be drawn up with a front like two sides of a square, it is far worse to be open to an attack which would require such a formation without offering any front at all towards one of the threatened sides.

Having chosen such a position, and made such a faulty disposition of his troops within it, it was almost inevitable that Benedek should get the worst of the battle, provided the Prussians brought their whole force into action on the same day: but according as he handled his men skilfully (or not), would probably depend whether he merely failed to maintain his ground, or whether his forces were routed. Here again he seems to have failed in the ability required and expected of him, and his failure was in this wise.

There is no more elementary or more important principle to be observed, than that a general should keep about one-fifth part of his army in reserve, subject solely to his personal orders; and it is a simple test of his tactical skill whether he seizes the right crisis for employing it. The present accounts of the battle of Königgratz leave it uncertain what the exact arrangements were in this respect, but there seems to have been, in rear of the line exposed to any attack, at least double the proportion of men usually so disposed. In the absence of information to the contrary it would seem that these troops, consisting of two entire corps, were not retained under Benedek's personal orders, but were entrusted with supporting the first line

* Other evidences of want of capacity have been attributed to him, but, even supposing them to prove well founded, their establishment would have required the introduction of matter unsuitable to this outline.

† Rüstow; Der Krieg von 1866, p. 219.

according to their own commanders' discretion. It is at any rate a matter of fact that when Chlum was found to be in the enemy's hands, when the very occasion arose for which reserves are kept back, Benedek had no mass of troops ready for retaking it. The account given by the "Times" military correspondent who was present with the staff at the moment, shows what an absence of provision there was; and other accounts only corroborate the same general view; the first detachment sent to recover Chlum consisted of only two battalions, and the Commander-in-Chief himself rode over the field to look for more. Whatever new light may be thrown on the transactions of the day, I cannot think it possible that this will be satisfactorily explained.

Thus, as a strategist, the trusted leader of the Imperial forces was powerless to arrest the course of events; as a tactician he failed to handle the troops skilfully in battle; and with his failure the last chance of success was lost to the Austrian arms.

Here, to avoid taxing your attention too much, I must draw to an end. The foregoing remarks suggested themselves to me as being likely to convey to an un-military audience some idea of the causes to which the Prussian victory was due. To military listeners I should have preferred to touch lightly on the national and other general features, devoting the space thus saved to showing in what points the late events have illustrated military theories, or are likely to influence future practice; or I should have treated the subject at greater length, and reserved that portion for a second lecture. The peculiar circumstances of the case have prevented me from now doing either one or the other. I can therefore only mention one or two points which it would be instructive for a military student to examine.

In the first place the needle gun was used under circumstances so exactly calculated to develop its superiority and exaggerate its moral effect, that all its merits as a quick-loading weapon were brought into play, whilst none of the anticipated objections about the difficulty of supplying ammunition were felt. I only met with one case of difficulty in that respect, but it was an important example,* and it seems to me still an open question how far disasters may in future attend on a want of proper supplies caused by accident or mismanagement. If it could be reasonably expected that ammunition would never be wasted, there would be little to fear about its being exhausted. But young and half-trained soldiers, such as fill the ranks after the first two or three years of a war or even sooner, always have been subject to a habit of useless firing, and it will need a wonderfully careful supervision, if not a radical change in human nature to prevent their doing so. To expect that they should remain steady in front of an enemy, after the ammunition is exhausted, is to expect more than that they should refrain from wasting their shots. The American experience, I have heard, was that if the machinery of a man's repeating rifle went wrong in action, or if by any other cause he was unable to go on firing, he threw down his weapon, and to use their own vulgar but expressive term, he "skedaddled." The Prussians brought into the field men of a different stamp and the war did not sweep them off, their successes also were generally easily won, consequently on this important question no sound experience has been gained.

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* See note D, p. 381.

The great quantity of artillery which was attached to both armies was a noteworthy feature of the war, and it was employed in a manner which shows that this arm is even more than ever relied on for supporting and covering the movements of other troops; consequently its mobility, or facility of movement, is also more than ever important. Field artillery, if it is not all equipped as horse artillery, will at least be expected to move faster than foot soldiers, and to precede, rather than accompany, the bodies of infantry. I am happy to add that officers who have examined the artillery of foreign armies report that none is better qualified than our own to carry out this duty.

A comparison between the disposable means in Frederick the Great's time, and the general mode of operations on the same scene of action under his leadership, with those of the late war, are well deserving of notice. For some of these you may refer with advantage to Carlyle's history, in which there are several passages relating to the Silesian contests which seem to have almost a prophetic application, so closely do they apply to recent incidents. I wish I could quote them here, but I have already detained you too long, and I must not abuse your patience by adding another word to this unsophisticated account of the war in 1866.

APPENDIX.

CHRONOLOGY OF THE PRINCIPAL EVENTS OF THE WAR.

June 12, The ambassadors recalled from Berlin and Vienna.
" 14, Division in the German Diet on the motion brought forward by Austria against Prussia.
" 15, Invasion of Saxony, Hanover, and Electoral Hesse, by Prussian troops.
" 23, The First Prussian Army and the Elbe cross the frontier of Bohemia.
" 24, Battle of Custozza in Italy.
" 26, Actions at Liebenau, Turnau, Podol, and Hunerwasser by the First and the Elbe armies. The Second Army crosses the frontier.
" 27, Actions at Trautenau and Nachod, by the 1st and 5th Prussian Corps.
" 28, Further actions at Burgersdorf, Skalitz, &c.
Münchengratz carried.
Capitulation of the Hanoverian army at Langensalza.
" 29, Action at Jaromirz; Gitschin carried.
July 3, Battle of Königgratz.
The army of the Maine engaged at Dermbach, &c.
" 4, Further actions at Neidhardshausen, Wiesenthal, &c.
" 5, The Prussians cross the Elbe.
July 8, In Italy, Gen. Cialdini again crosses the Po.
" 10, Actions at Kissingen and Nudlingen.
" 11, Cavalry action at Tischnowitz.
" 12, The Austrians begin to retire from Olmutz. Archduke Albert assumes command.
" 13, Action at Laufach.
" 14, Action at Aschaffenburg.
Cialdini occupies Padua.
" 15, Action at Tobitschau.
" 16, The Prussians enter Frankfort.
" 18, The King's head-quarters moved to Nikolsburg.
" 20, Naval Battle of Lissa.
" 21, The Prussians resume operations from Frankfort.
" 22, Battle at Blumenau; a truce begun at noon, after which no further hostilities took place on this scene of action.
" 24, Action at Tauber-Bischofsheim.
" 25, Actions at Helmstadt, Gerchsheim, &c.
" 26, The Prussians reach Wurzburg.
Preliminaries of peace signed at Nikolsburg.
Aug. 4, The King re-enters Berlin.

NOTE A. *Composition of Army Corps.*

The ordinary composition of the Prussian and Austrian Army Corps, so far as the combatants are concerned, was as follows:—

Prussian Army.

A CORPS contained about 24 battalions of line infantry, 2 battalions of light infantry (Jägers); 24 squadrons of cavalry, and 17 batteries: in numbers it represented about 25,000 foot, 3600 horse, and 102 guns.

It consisted of 2 infantry divisions, a cavalry division, and an artillery reserve.

Each infantry division contained two brigades of line infantry (with 2 regiments of 3 battalions each) a battalion of Jägers (or a fusilier regiment with 3 battalions), a regiment of cavalry (4 or 5 squadrons), and 24 field artillery guns.

A cavalry division contained two brigades, 16 or 18 squadrons in all; and 1 or 2 batteries of horse artillery; i.e. 6 or 12 guns.

The artillery reserve for a corps consisted of 4 field batteries, and 2 or 3 horse batteries; 36 or 42 guns accordingly.

A battalion consisted of about 1000 men, and a squadron of 150 horses: a battery contained 6 guns.

Austrian Army.

A CORPS contained about 28 battalions of line infantry, 2 battalions of light infantry (Jägers or Grenzers), 10 squadrons of cavalry, and 10 batteries of artillery; in numbers about 28,000 foot, 1500 horse, and 80 guns.

It consisted of 4 infantry brigades, a cavalry brigade, and an artillery reserve.

Each infantry brigade contained two regiments (6 battalions) of line infantry, and a battalion of Jägers; with one battery of field artillery.

A cavalry brigade contained two regiments (10 squadrons) of cavalry, and a horse artillery battery.

The artillery reserve of a corps contained 2 heavy field batteries, 2 horse artillery batteries, and a rocket battery.

A battalion contained about 1000 men, a squadron 150 horses, and a battery 8 guns.

It will be observed that the division is omitted from this organization.

The change has been made since 1859; it is now only employed for infantry when two or three brigades are required to act as a detached force; for cavalry however, it is still retained as an independent unit, a complete army comprising one or more cavalry divisions in addition to the corps as above described.

A cavalry division contains 3 brigades (2 heavy and 1 light), and 3 horse artillery batteries; in numbers about 3900 horse and 24 guns.

An "army artillery reserve" is also sent into the field as a unit independent of the Corps; its normal composition is to have twice as many batteries as the army has corps; that is to say, an army of 5 corps would have an artillery reserve of 10 batteries.

The Prussians found it desirable to mass the cavalry divisions of the several corps into large divisions before the battle of Königgratz. They also found the division a more convenient unit than the corps for infantry arrangements. The fact is that the organization by corps is more applicable to widely extended operations than to the handling of large masses of men on the same field of action.

NOTE B. to p. 357.

Since this lecture was sent to the press an article has been published in the Edinburgh Review (No. 256, April, 1867), which gives very authoritative accounts of the Prussian plans and movements, especially those of the 2nd or Crown Prince's army, in the early and decisive periods of the campaign.

According to this writer the only chance of success for the 2nd Army seemed to be by throwing the 1st and the Elbe Army rapidly forward upon Gitschin, wherefore the forces placed under Prince Frederick Charles' orders were made strong enough to bear down any opposition which, from what was known of the Austrian positions, he was likely to encounter.

With the execution of this scheme on the Prince's part the writer is not satisfied, considering that he acted with a wariness and a caution inconsistent with the attainment of the main object in view. He also quotes a disparaging criticism, and an unfavourable comparison between Prince Frederick Charles and the Crown Prince, from a German military periodical; probably

one of those which caused the antagonism and dissatisfaction mentioned in the note at p. 357.

Note C, to pp. 360 and 362.

The article in the Edinburgh Review attributes all the Prussian arrangements to the King's Staff, denying any merit to Prince Frederick Charles, and pointedly stating that—

"It would have required more genius than Prince Frederick Charles possesses to discern, when he overlooked the position of Sadowa and Chlum, on the morning of July 3rd, that it was dangerous to attack it before being assured of the near approach of the Crown Prince."

The application for a corps to be sent out by the 2nd Army referred only to making a reconnoissance from that direction, and had already been ordered by the Crown Prince before the messenger arrived. The article contains the King's written instructions dated 2nd July, 11 p.m., which after premising the grounds for expecting an encounter at Sadowa the next morning, concludes with,—

"Your Royal Highness will take the necessary measures to support the 1st Army with all forces against the right flank of the expected march of the enemy, and will attack as soon as possible."

Similar instructions were sent to the Elbe Army. Those addressed to the Crown Prince did not reach him at Königinhof till 4 a.m., and it was 5 before his own orders could be despatched. Part of the Guard was however on the spot, and it fortunately happened that the 6th Corps had had previous orders to march in the early morning on a reconnoitring expedition towards Josefstadt.

The description of the further movements and of the action is generally in accordance with the account in the lecture. It is highly interesting to learn the exact state of the case about the arrangements for engaging in so important a battle. The story about its entire fate turning on the chance of Prince Frederick Charles' aide-de-camp escaping capture by Austrian patrols, and evading the other risks attendant on a midnight journey, fails to hold its place as an historic fact. It had always an improbable appearance that the Prince should have offered battle on his own responsibility when the King was near at hand, and had assumed the general command.

Note D. *Expenditure of Ammunition.*

The instance referred to at p. 377 occurred in the operations of Goeben's division of the Maine Army, and is thus narrated in an account, evidently written by some one present on the occasion, which appeared in the "Kölnische Zeitung" of 21st August, 1866.

"Bischofsheim was defended only by the 55th Regiment, the Lippe battalion, and two companies of the 15th Regiment, and out of that number five companies did not fire a shot, for they were partly posted as reserves in Bischofsheim, and partly employed in continually bringing up fresh ammunition to the companies standing on

the other side of the Tauber. This was especially the occupation of the Weissig company, whose men laid down their arms and knapsacks and waded through the Tauber; the bridge being impassable under the heavy fire from the enemy's side. These relays of ammunition were of the first importance to the hot continuous and rapid firing that was kept up, for without it the position would have been untenable. The firing was so heavy that several men expended twice over a full supply of ammunition, (zweimal die ganze chargirung geschossen)."

The enemy, according to another part of the account, made five attacks, extending over three hours; and within this short time, of which not more than one-half, probably, was spent in anything like close fighting, some of the men fired 120 rounds of ammunition, and would have been left without supplies if a part of the combatants had not been employed to replace it as it became spent. The reserves could not be brought up close enough for the purpose, as would often happen in field engagements.

To men who will coolly judge and take advantage of the best moment for firing a shot it is undoubtedly desirable to give a weapon which can be discharged with the utmost possible rapidity. The doubtful point is whether young and imperfectly trained soldiers, who are apt to fire nervously as a mere relief to their disordered minds, will, on the whole, do better service with such a weapon; or whether the facility of firing away ammunition will only increase the trouble of supplying it, and the risk of such alarm as is liable to result from its being exhausted.

Results so brilliant have attended on the use of breech-loaders against muzzle-loaders that their general adoption has become imperative; we have next to see whether they tend to hamper or to facilitate the plans of a commander in conducting a campaign, when they are possessed by both the contending armies.

Note E. *Casualties.*

Although such details as the exact number of casualties do not properly fall within the scope of a lecture, it may be worth while to insert a few particulars on the subject, more especially as the campaign was distinguished by a great disproportion of loss between the two sides, and by an inordinary number of prisoners captured on the field of battle.

Prussian Casualties.

Loss at Königgratz:—

	Officers.	Men.	Total.
Killed	75	1097	1172
Wounded	252	8272	8524
	327	9369	9696

Loss of the 7th Division, which was the most severely engaged in that action, (from Rüstow):—

	Officers.	Men.	Total.
26th Regiment	24	682	706
27th "	27	497	524
66th "	13	464	477
67th "	16	401	417
	80	2044	2124

This would be $\frac{1}{5}$, or rather more, of the strength.

Total loss during the war:—

Killed ..... 2,910 officers and men.
Wounded ..... 18,576 " "

21,486

Colonel Rüstow gives it as 869 officers and 22,657 men; total 23,526.

Austrian Casualties.

The following statement is compiled and arranged from a paragraph in the "Times" (6th May, 1867), which was extracted from the 13th Annual report of the Statistical Commission of Austria. The results refer to the "War with Prussia," and perhaps include the casualties in the Austrian Contingent present in the operations on the Maine, but these would be too small to make much difference in the numbers belonging to Bohemia.

	Force engaged.			Killed.		Wounded.		Missing.		Total.
INFANTRY:—	Officers.	Men.	Total.	Offcs.	Men.	Offcs.	Men.	Offcs.	Men.	
Line	6,686	249,243		428	7,997	1,138	21,545	352	32,710	
Jägers ...	1,118	42,871	317,192	116	1,642	214	4,399	50	6,394	87,600
Grenzers.	480	16,794		4	68	22	328	2	191	
CAVALRY:—										
Heavy ...	312	7,008	28,010	10	148	33	205	23	890	3,689
Light ...	883	19,807		12	258	54	451	32	1,573	
Artillery	513	22,245	22,758	17	292	44	868	20	1,331	2,572
Other services.	940	38,323	39,263	—	2	4	9	—	175	190
	10,932	396,291	407,223	587	10,407	1,505	27,805	483	43,264	94,051
					10,994		29,310		43,747	
INFANTRY:—	Proportionate loss.									
Line	In every 1000 engaged ...			64	32	170	86	53	131	
Jägers ...	" ...			104	38	191	103	45	149	
Grenzers.	" ...			8	4	46	20	4	11	
CAVALRY:—										
Heavy ...	" ...			32	21	106	29	74	127	
Light ...	" ...			14	13	61	23	36	79	
Artillery	" ...			33	13	86	39	39	60	
Other services.	" ...			—	1	4	2	—	35	
	General average			36	17	95	43	36	70	

It will be observed that the general average of officers killed and wounded is 131 per thousand, whilst that of the men is only 60: on the other hand the proportion of men missing is just double that of the officers. It is to be expected that officers, whose duty it is to lead, should fall in greater proportion than men, but where the difference is strongly marked it is a certain proof that they were not cordially supported. Exact statistics on this point can only be produced from accurate returns of the officers and men present under fire, but general conclusions may be drawn by comparing the losses with the proportionate number of officers as shown by the organization. Colonel Rüstow states that the loss among the Prussian officers, thus computed, was little, if anything, in excess of that of the men.

The Austrian losses in various actions are given as follows in the Edinburgh Review from an official list :—

	Killed.	Wounded.	Missing.	Total.*
Hunerwasser	140	170	460	778
Trautenau	681	1,702	1,205	3,589
Skalitz	2,455	3,360	5,850	11,645
Königgratz	4,220	12,015	22,684	37,919

Books and Memoirs on the War of 1866.

Chesney, C. C., Captain R.E., and Professor of Military History at the Staff College. An account of the operations in Western Germany and on the Maine, In Blackwood's Magazine for January 1867.

Cooke, A. C., Lieut.-Colonel.R.E. Short summary of the campaign in Austria of 1866. In the Professional Papers of the Royal Engineers, Vol. XV. Also reprinted and published separately.

Edinburgh Review. An article in the number for April 1867.

Grenzboten, die; published at Leipsic; Nos. 45 to 51 contain an account of the War, referred to by the writer in the Edinburgh Review.

Hamley, E. B., Colonel R.A. An account of the operations in Bohemia; in Blackwood's Magazine for August, 1866.

Hozier, H. M. Lieut. 2nd Life Guards (previously of the Royal Artillery). The Seven Weeks' War; based on the letters which appeared in the "Times," 1867, 8vo. 2 vols. 28s.

Reilly, W. E. M., Lieut.-Colonel R.H.A. Report on the Artillery, Transport arrangements, &c. of the Prussian army in the Campaign of 1866. R.A. Institution.

Rüstow, W. Oberst-Brigadier. Der Krieg von 1866, in Deutschland und Italien politisch-militärisch beschrieben, 1866, Zurich, 8vo. (Colonel Rüstow is one of the best known military writers on the Continent).

Wachenhausen, Hans. Tagebuch vom Oesterreichischen Kriegschauplatze. Berlin 1866.

Winterfeld, C. von, Geschichte der Preussischen Feldzüge von 1866.

Westminster Review; April, 1867. An article on Italy and the War of 1866.

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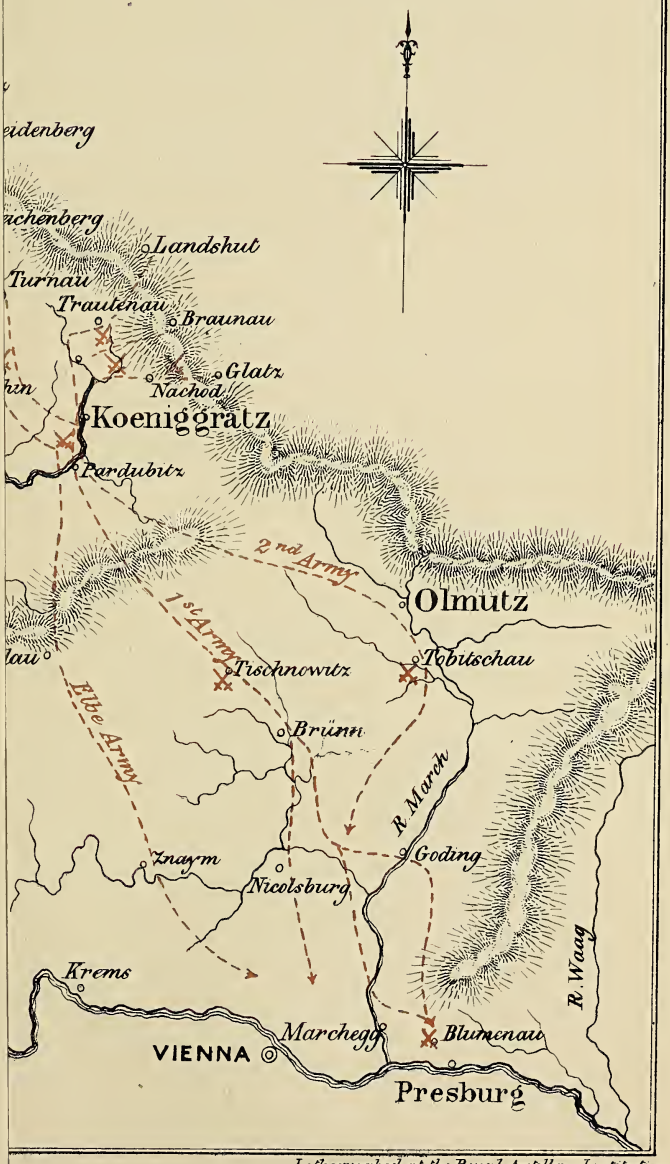
* These figures are correctly copied, but the details are not in accordance with the total.

PLAN I

SKETCH MAP

To show the General Movements.

Prussian lines of March.

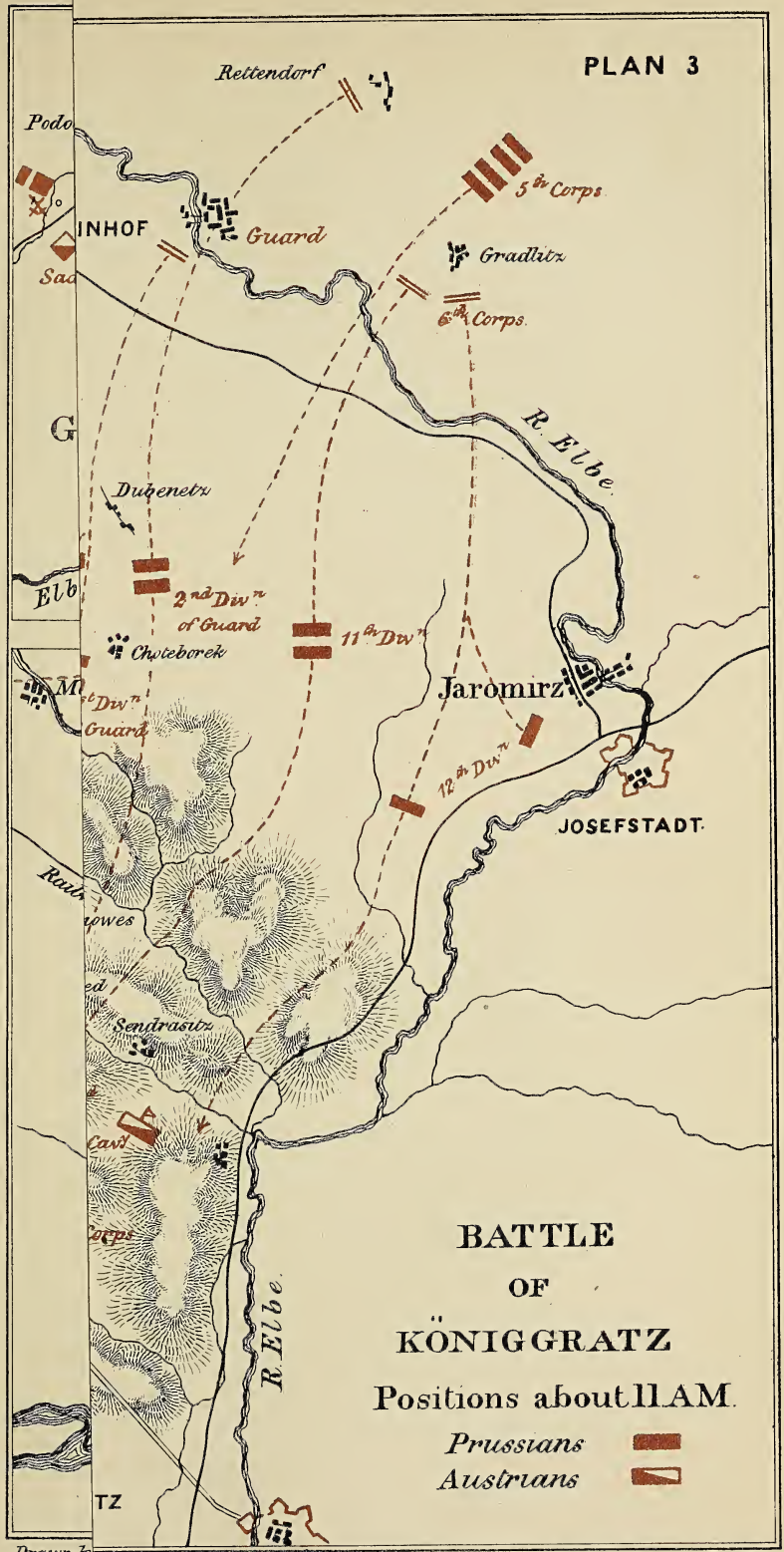


Lithographed at the Royal Artillery Institution

Drawn by L.t Col F Mulier R A

Lithographed at the Royal Artillery Institution

Scale of 0 50 100 Miles



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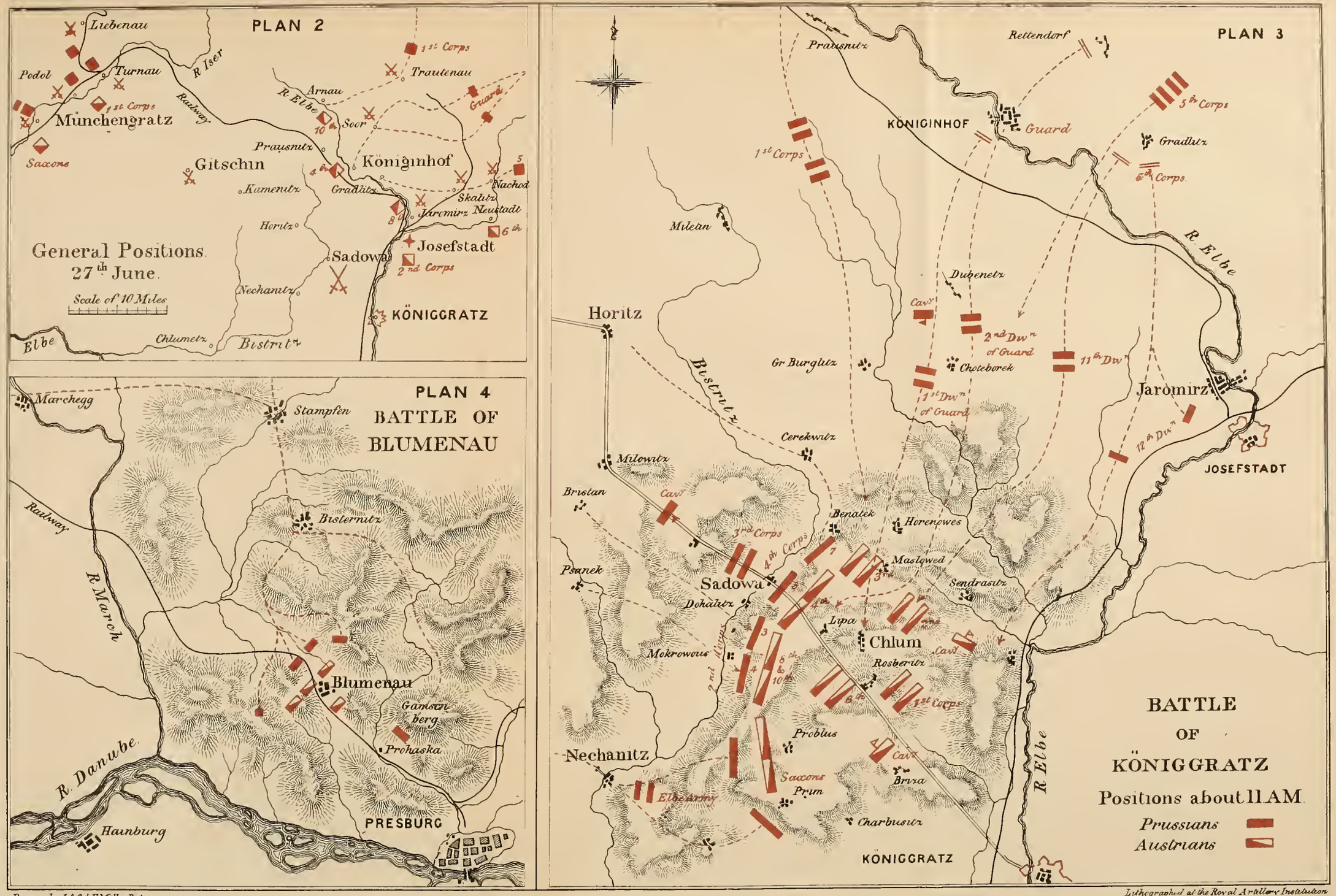

PLAN 2
Liebenau
Podol
Turnau
R Iser
Railway
Münchengratz
1st Corps
Saccons
Gitschin
Arnau
R Elbe
10th
Soor
1st Corps
Trautenau
Guards
Prausnitz
Königinhof
4th
5
Nachod
Kamenitz
Gradlitz
Skalitz
Jaromirz
Neustadt
8th
6th
Horitz
Josefstadt
Sadowa
2nd Corps
General Positions
27th June.
Scale of 10 Miles
Nechanitz
KÖNIGGRATZ
Elbe
Chlumetz
Bistritz
PLAN 4
BATTLE OF
BLUMENAU
Marchegg
Stampfen
Railway
R March
Bisternitz
Blumenau
Gamstenberg
Prohaska
R. Danube
Hainburg
PRESBURG
Drawn by Lt Col F Miller R A
Prausnitz
Rettendorf
PLAN 3
KÖNIGINHOF
Guard
5th Corps
Gradlitz
6th Corps
1st Corps
R Elbe
Milean
Dubenetz
Cavy
2nd Dwn of Guard
11th Dwn
Horitz
Gr Burglitz
Choteborek
1st Dwn of Guard
Jaromirz
12th Dwn
Bistritz
Cerekwitz
JOSEFSTADT
Milowitz
Bristan
Cavy
Benatek
Horenowes
3rd Corps
4th Corps
Maslowed
Psanek
Sadowa
Sendrasitz
Dohalitz
Lipa
Chlum
Mokrowous
Rosberitz
Cavy
2nd Corps
6th & 10th
1st Corps
Problus
Nechanitz
Cavy
Saccons
Prim
Brixa
Elbe army
Charbusitz
R Elbe
KÖNIGGRATZ
BATTLE
OF
KÖNIGGRATZ
Positions about 11 AM
Prussians
Austrians
Scale of 1 ¼ ½ 1 2 3 4 5 Miles
Lithographed at the Royal Artillery Institution

THE SHRAPNEL OF THE PAST.

BY MAJOR-GENERAL W. B. GARDNER, R.A.

THE following paper is based upon notes which were originally compiled with a view to the instruction of a class of non-commissioned officers and gunners in the use of *one* of the many projectiles which, in the ordinary course of service, they might be called upon to handle.

Since this compilation was made, a continental war has occurred, which for important results and brevity might well equal some of Napoleon's wonderful campaigns.

It has thrown upon certain important questions much light; and the anxiety of Europe to re-arm and recruit, at any cost, shews how strong a feeling this contest has created.

From the large number of guns brought into the field on both sides, and from the well known high military character of the belligerents, there was reason to suppose that one or more remarkable instances of the application of artillery would have arisen, or that some technical principles would have been illustrated. But it does not appear, whatever may have been the cause, that these masses produced proportionate effects; that is to say, such effects as *we*—without boasting or arrogance, because spontaneously avowed by our opponents—have obtained in former wars.

One thing, however, was evolved which occasioned some surprise and even incredulity amongst those who had not gone into the question, namely, Prussian smooth bores having in one instance beaten off Austrian rifled guns.

Amongst ourselves, changes in infantry arms and tactics have led to grave doubts as to the relative value of "the three arms." We are told that infantry will carry all before them, or that whilst the general power of artillery is great, our chief reliance should be placed on common shell; or again, if shrapnel and similar shells are used, the idea of bursting them in flight should be abandoned, and that we must trust to percussion fuzes. In other words, we must follow the method in fashion amongst the half-trained gunners of the continent, who in some instances during the late war, made their first acquaintance, when actually under fire, with the guns and projectiles they were to use!

Whatever system of training or recruiting may be adopted in England, it is devoutly to be hoped such mistaken notions and ignorance may never take root among us.

However, the needle gun, or something more powerful has operated to shake our faith, not only in ourselves, but also in a projectile, the shrapnel, which was at one time so highly valued by the Duke of Wellington, that its construction and use, were recommended by him to be kept secret.

Hearing these things discussed I was induced to investigate the question for myself, and the result of my labours is now offered, for what it is worth,

as a contribution to the History of the Regiment. For the remarks at the end of the paper (on training) I alone am responsible.*

It may fairly be asked here, has not the study of our Regimental History been greatly neglected? Are our men worse drilled than they were in 1803? Is the projectile of which we are treating itself inferior? Has the race deteriorated,—that is to say, have we less of the coolness, and fewer of the good qualities required in the artilleryman, than we had formerly? That there has been no falling off in the *quality* is evident from recent occurrences. For example, one of our brother officers, writing in 1857, recommends for distinction, not one, but a large number of men of his battery, for exhibiting under many trying circumstances, "peculiar, cool, artillery courage." On another occasion, a magazine having been blown up in a siege work, rendering for the moment all the guns in the battery but one, unserviceable, and drawing upon it a heavy fire from the Russians—that one gun was worked as coolly as if nothing had happened, evincing as the despatch of the 21st April, 1855, expressed, "the coolest judgment and most determined gallantry."

In an introductory notice it is quite unnecessary to multiply instances of the existence of this soldier-like quality of "cool judgment" amongst us. It abounded formerly, and we may reasonably hope it will not be wanting in future.

The question of the projectile may be dismissed at once.

A remark may be made however in passing, respecting the manner of carrying on the annual practice and drilling. Is the firing over smooth sands or water sufficient for all purposes of instruction? Is the quickness of laying guns and fixing fuzes, at preliminary drills, as much considered as it ought to be? and, in fact, as a rule, is not the practice made too easy?

On service the conditions of practice may be these: range unknown—atmosphere murky—country open, like the Downs, or enclosed like Devonshire—surface soft or hard—smooth, undulating, or rugged—view concealed by brushwood, or standing crops—sight disturbed by wind, rain, snow, dust or smoke—wheels out of level—noise, confusion, everything hurried.

In peace, as a general rule, the practice is carried on quietly and under the most favourable conditions for sending in a good "Range Report." This is to be commended as far as it goes, but should be regarded as recruits practice, which requires to be supplemented by work over undulating or broken ground, the firing occasionally as rapid as possible.

At any rate, whatever may be considered the most suitable projectile for field artillery, let there be no doubt on the subject. The gunner must know by experience what he can, or cannot do, at various ranges, conditions of ground and targets: what to undertake with reasonable prospect of success, and when from difficulties of ground, or other cause, his fire should be withheld. Thorough training is worth any expense; an ignorant artilleryman is only in the way; and when all our means of instruction are exhausted, we

* The Committee have been compelled, most reluctantly, to omit this portion, owing to the great expense of publishing it with adequate illustrations; but they hope that the recommendation they have made on the subject may lead to its publication by Government.—A. H.

should never forget that war is not "a game of chess," but an affair in which divers causes are in continual operation to thwart the desires of the commander. And yet experience proves, that well trained men are obedient, calm, and steady, even in times of great excitement.

In an enquiry of this nature, it is but just to go back to the period when long-range case or grape was first thought of, to trace the progress of the projectile as far as possible, and shew what it has been the means of effecting.

That it failed occasionally to realize the somewhat sanguine views of the inventor is evident, but the failures bear on the whole a very small proportion to the successes, notwithstanding the unpractised hands into which the new projectile very often fell.

A small memorandum of Shrapnel's is the first indication we have of the great idea, the carrying out of which occupied the best years of his life :—

"Exhibited to General O'Hara, then commander at Gibraltar in the year 1787, a new method of extending the use of grape shot, or case shot, to the utmost range of ordnance. When General O'Hara publicly proved the garrison of Gibraltar secure from the attack of gun boats, as they were undaunted by the fire of round shot."

In the archives of the Royal Military Repository, an account was subsequently discovered, by Captain Strange, R.A., of the very experiment referred to above,—

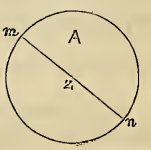
"An experiment made at Gibraltar, the 21st December, 1787, before His Excellency Major-General O'Hara, with an 8-inch land service mortar; having its shell loaded with 200 musket balls, and powder only sufficient to open it : fired upon the sea, from an eminence 600 feet above its surface. Weight of shell 58 lbs., weight of powder in the chamber of the mortar, 1 lb. 3 oz.

Order of fire.	Diameter of circles the balls spread.	Weight of powder in the shells.	Distance the balls were thrown.
	ft.	oz.	yds.
1	19	In a flannel	1100
2	26	cartridge..... 3	
3	29	Loose 9	
4	27		
		Total..... 12	

"The shells opened half a second before they would have reached the surface of the water.

"When the shell opens, the balls proceed in its path, not having any other motion communicated to them, for the flame which separates the shell, acting in all possible directions with equal force, presses upon the whole surface of each shell.

"Supposing *A* one of the balls, *mn* a diameter, and *z* the centre. The force of the flame upon the two points *m* and *n*, in the surface, will be in the direction *mz*, *nz*, towards the centre *z*, which being equal and contrary is destroyed; and as the number of points in one hemisphere are equal and opposite to those in the other, the ball must consequently remain at rest.



"The splinters of the shell describe curves generated from the projectile curve, and impulse of the flame that separates them; they will therefore proceed in nearly the path of the shell, when the velocity of the shell much exceeds that which the splinters are impelled with.

"N.B.—A 13-inch shell may be loaded with 1000 balls; a 10-inch with 550; an 8-inch with 200; a 32-pr. shell with 110; a royal with 80; and a coehorn with 50. Were shells cast thinner, the effect would be still greater, and less powder required to open them.

"The balls may be spread more or less; by opening the shell, at a greater or less distance from the object.

"The shells broke into more than twenty splinters, all of which fell close round the balls.

"HENRY SHRAPNEL,
"Lieut. Royal Artillery."

It was early found that the effect of round shot or case, against infantry or cavalry in the field, was under many circumstances very trifling indeed, and an attempt was made to improve artillery fire by projecting shells horizontally. Common shell having been long used with mortars, it appears to us—with our present experience—to be an easy step from a mortar shell to a gun shell; but, in fact, the adaptation was attended with many difficulties, involving, as it eventually did, a revolution in the construction of field guns, and the introduction of howitzers.* It then became an object to fire shells with high velocities.

We made experiments in England in the same direction, as appears from the following extract from Lawson's MSS., R.A. Institution:—

"Experiments were made on Acton Common in 1760, to fire coehorn and royal shells from 12 and 24-prs., in order to be applied to the sea service; but as the shells were found frequently to burst in the guns, it was thought too hazardous to introduce them on board ships of war."—*Lawson's MSS.*

These premature bursts also occurred at Gibraltar during the celebrated defence of that place, for Herriott records that "Lieut. Cuppage, R.A. was dangerously wounded by a splinter of a small shell which burst immediately after being discharged from the Rock gun." Lieutenant Cuppage, however, lived to do good service, and especially as Inspector of the Royal Carriage Department, into which he introduced special machinery, and by his exertions placed the establishment far ahead of anything of that kind in any part of the world.

It was at the siege of Gibraltar that Lieutenant Shrapnel is supposed to have received his first ideas of the projectile which now bears his name. It is stated that of 2000, 24-pr. shot fired from the Rock, only twenty-six Spaniards had been observed to have been carried off killed or wounded;

* Howitzers were used in the allied (Anglo-Dutch) army in the war of 1688—'97, and became known to the French artillerists by some of them being captured at the Battle of Neerwinden in 1793.

and of the large mortar shell, Drinkwater says, "they sunk so deep, that the splinters seldom rose to the surface. An experiment was therefore recommended by Captain (now Major) Mercier, of the 39th Regiment: namely, to fire out of guns 5½-inch shells with short fuzes, which were tried on the 25th, and found to answer extremely well. These small shells, according to Captain Mercier's method, were dispatched with such precision, and the fuzes calculated to such exactness, that the shells often burst over their heads, and wounded them before they could get under cover."

The French account of the attack of Gibraltar makes special mention of the traverses they were obliged to construct to protect themselves against these small shells :—

"These traverses were another novelty peculiar to this siege. * * * The sole object of these traverses was to protect the men against mortar shells, and against a species of howitzer shell fired from short guns, a murderous weapon, but from which we could protect ourselves, by placing the traverses on the side opposite to the fall of the shells and grenades, &c."—*Conseil de Guerre privé, &c.*, 1785.

Upon one man at least the experience of this siege was not lost. Shrapnel left Gibraltar in 1790, and after two years pondering over the scheme which was to do such honour to the Regiment, sent the following modest "remarks" to the Master-General of the Ordnance :—

Remarks on the flight of grape, and case shot, with proposals for firing them in a more collected manner.

"Having considered that the present mode of firing grape would admit of improvement, and that experiments might be made for that purpose, on some foundation, I have submitted such proposals as appear to me preliminary steps; contributing what little I am able, which might tend to its advancement.

"The object I have in view, is to increase the ranges of grape shot, by producing a collected fire at long distances, and to preserve the cylinders of brass ordnance from the injury they are now subject to.

"The third cause attributed to the spreading of case and grape shot, is the resistance of the air, which difficulty is to be surmounted on the principle of combining the load, for a certain space of time, during its flight in the air; now as the resistance of the air becomes less and less* every instant to the shot in its motion, whatever is made sufficiently compact to withstand its first obstruction, will most probably remain unaltered during the remainder of its flight in the range, which quite defeats the intention of using grape shot, as the load would always be combined.

"In the consideration of this circumstance, I am obliged to have recourse to a shell filled with balls, and containing a small quantity of gunpowder, only sufficient to open it, at a short distance previous to its execution; by which means the fire will be equally severe at all distances, and exceedingly practicable in such situations where sufficient time may be allowed for loading. Those officers who are better acquainted with service than I am, may judge of the variety of situations such kind of firing may be serviceable, and I can venture to remark, that it succeeds in the effect which is proposed, having had an opportunity of making an experiment which is now submitted.

* "Above the horizontal plane on which the piece is situated."

Experiment.

Nature of ordnance, 8-inch mortar.	No. of rounds fired, 4.	Mean diameter of circle the shot spread, 25ft.	Weight of powder in the shell, 12 oz.	Shell opened before it reached the object ½ sec.	No. of shot in the shell, musket balls 200.	Number of splinters shell broke into, 20.	Distance the balls were thrown 1100 yds.

"By this experiment, with a well laid mortar, almost the whole of 200 balls and 20 splinters of a shell, may strike the deck of a large ship at 1100 yards distance, and the whole of the load would fall within a bastion, at any distance within the range of the mortar; I think this mode of firing might successfully be applied in the loading of shells from guns in the same manner. A 32-pr. shell will contain 110 balls, a 24-pr. 80 balls, and a 12-pr. shell 50 balls.

"It will give me very great satisfaction should these proposals prove beneficial to the service; and I shall feel myself happy if I am at all instrumental in the introduction of the proposed methods of firing grape shot.

"HENRY SHRAPNEL,
"Lieut. of Artillery."

"CHATHAM BARRACKS,
"February 11, 1792."

The Board of Ordnance cannot be accused of inactivity, for on the 17th of the same month, the Duke directed the President of, what was then, the Ordnance Select Committee, "to convene a Committee of Colonels and Field Officers of the Royal Regiment of Artillery at Woolwich, to examine proposals of Lieut. Shrapnel for firing case and grape in a more collective manner."

There is a break in the records here. Shrapnel goes on foreign service, and has probably frequent occasion to remark the want of a suitable projectile to meet the varied circumstances of attack and defence which occurred during these campaigns. He returns to England, resumes his labours, and is termed "an enthusiast," of course.

Dated Woolwich, August 9th, 1802, is found "A Table of practice with the proposed new method of firing case shot.

"Brass medium 12-pr., charge 1lb., elevation $2\frac{3}{4}°$; shell holding 44 carbine balls, bursting charge 4 oz.; and a 24-pr., charge 2 lbs.; 74 bullets in shell; bursting charge, 8 oz.; penetration 2 inches."

The first really cheering letter to the "enthusiast" appears to be from Colonel Boag, R.A., his old companion in arms at Gibraltar.

WOOLWICH,
August 18, 1802.

Dear Shrapnel,

It is with great pleasure I congratulate you upon the success of your several experiments here. Major Hamilton and the officers who were present at the experiments with shells loaded with ball, express the highest satisfaction.

Loading shells fired in that manner from guns will be excellent against cavalry, or working parties, or bursting over boats attempting to land troops; in short it will be of the greatest utility in any service.

I remain,
(Signed) JAMES BOAG.

Major Shrapnel,
Royal Artillery.

The Committee proceed very cautiously.

From the Committee at Woolwich, to the Honourable Board,—

PRESENT.

Lieut.-General Drummond, Major-General Lloyd, Colonels Blomfield, Lawson, Douglas; Lieut.-Colonels Smith, Laye, Dukernett, Miller.

WOOLWICH,
June 7, 1803.

Sir

Be pleased to inform the Honourable Board of Ordnance that in obedience to their orders conveyed in your letter of 3rd instant, I convened a Committee of Colonels and Field Officers who attended the experiments carried on by Major Shrapnel in firing shells loaded with ball, and they have to report that the effect of such fire appears to be very considerable, and would doubtless in many instances prove destructive to a great degree. The Committee in giving their opinion upon the effect of the invention, are desirous that the Honourable Board should be informed they do not take upon themselves to decide upon the policy of introducing it for general service, which they submit to the judgment of the Honourable Board, &c., &c., &c."

VAUGHAN LLOYD, Colonel Comdt.,
Major-General.

R. H. Crew, Esq.,
&c., &c., &c.

Shrapnel was now evidently working hard with great effect. His experiments must have been attended with success, for on the 4th of August, 1803, he was ordered by the Honourable Board "to go down to Carron with all convenient dispatch, to prove the shells, and forward them to Dublin for the service of Ireland."

"On this spot" he says, "the Firth of Forth which runs up within six miles of Falkirk, I have encamped my men, and have selected carronades for trying my fuzes," &c.

From a memorandum of his, it would appear that the Carron Company's orders were large. They delivered in

For Dublin...	September, 1803	.....	33,000
	October, 9, "	.....	2,262
	" 20, "	.....	1,502
	" 31, "	.....	26,336
	Dec., 31, "	.....	11,342
	Total...		74,442

of these, the significant number of 30,100 were "for the service of Ireland."

Possibly the Honourable Board took it upon themselves to decide upon the policy of adoption of the shell, the "service of Ireland" operating towards a settlement of the question. The Committee of Field Officers did not come to a decision until March in the following year.

The following letters are interesting, as shewing that the whole subject of the new projectile had been referred to Shrapnel. He appears not only to have conducted the proofs, arranged the fuzes, and determined the practice tables, but also to have settled, in some measure at least, the very stations to which the projectiles should be sent.

The postage of the following curious letter, which was not intended for publication, is 1s. 9d.

LIVERPOOL,
October 18, 1803.

Dear Shrapnel,

Your letter from Carron addressed to the Commanding Officer of Artillery at Liverpool, having been brought to Head Quarters, Prince William has directed me to acknowledge the receipt of it, and beg that you will send him *a proportion* of your new spherical case shot; the advantages of which he so much admires and approves.

But when making *this requisition*, it is but just that I should (in confidence) apprise you that his Royal Highness has neither artillery, or artillerymen in the district under his command, if from the first head we except, some heavy guns mounted (iron) upon standing carriages, and placed in an injudiciously selected and ill-constructed fort, and upon one or two batteries which bear the same description,—and under the second head (literally speaking) an old woman in the pay and hire, and appointed by the Right Honourable and Honourable Board, to act as Deputy or Provisional Master Gunner, for the sum of 1s. per diem,—and two invalid serjeants, who may I think with the greater propriety of metaphorical expression be denominated old women. I must now add, seriously speaking, that His Royal Highness wishes you (if you can) to send him *a fair proportion* of your shells, we having (in secrecy I venture to inform you) made such arrangements as will enable him to bring into the field, fifty pieces of ordnance complete in every other respect than a quota of experienced artillerists within the given time of twelve hours, should the enemy personally threaten these shores; and it is reasonable to expect *that* notice before it would be necessary to meet him in the field. The natures of ordnance upon the works here, are, 32, 18, and 6-prs.; not having yet (with my own eyes) seen any practice made with your shells, I shall feel superior pleasure in carrying on such at Liverpool, and afterwards reporting to you the great utility and vast advantages which in theory and report, they are already known to possess by your very sincere and faithfully obedient servant.

(Signed) EDMUND CURREY.

Major Shrapnel, A.D.C.
Carron, N.B.

Mark this, *complete*, "except a quota of experienced artillerists;" this is no uncommon mistake.

TYNEMOUTH,
August 17, 1803.

Dear Shrapnel,

I have this day written to the Board, and urged their giving directions for this district being immediately supplied with a large proportion of your shells direct from Carron, without the delay of the round *viâ* Woolwich.

The country owes you much for bringing forward your shells; too much delay has past, they ought to have been at the different posts long ago.

Believe me,
(Signed) F. LAYE.

LEITH FORT,
October 11, 1803.

My dear Major,

I have been so much from home for seven or eight days past at the Reviews at West Barus Camp and Musselburgh, and attending to Sea Fencibles and Volunteer Artillery (having so few of our own Corps), that I had not a moment till this day to practice with your shells, which answered most admirably, not one fuze missing,

and the desired effect of the balls fully shewn on the water * * * I have not yet received an answer from the Board, respecting my demand for a large proportion of shells, but I conclude their time is so much taken up, they consider you will be able to order me the quantity I may require without waiting the routine of office at such a juncture as the present.

I am, &c.
(Signed) W. P. SMITH.

COLCHESTER,
November 9, 1803.

Dear Shrapnel,

I have got some of your shells, and burst eleven as correct as possible at a target 850 yards.

Sir James Craig and other General Officers present were delighted at the effect.

I give my Officers great credit; they always fix their own fuzes, and it is now considered a disgrace to fire a blind fuze.

We managed your match very well with glue; but we are at a loss, as we want to fix them all (and mark the distance each shell will burst on the lid of the box) to prevent the match from rubbing off, and to secure it properly.

My fuzes with lids would be the exact thing, and I have written to General Drummond to request he will send those kind of fuzes down for me to fix them for the east batteries; all my shells in my brigades are ready fixed, and musket balls in my *common* shells (?) as I am satisfied everything depends on correctness and well fixing of the fuzes, I leave nothing to be done in the field where it must be done in a hurry; all my shells are fixed in the boxes so tight they cannot possibly move.

I mean to fix my battery shells at $\frac{4}{10}$, and $\frac{5}{10}$, to come in between the round shot range and the case shot, and mark the coins for $2\frac{1}{2}$ and 3 degrees elevation, and I am sure they cannot go far away.

(Signed) J. HARDING.

The "fuzes with lids" are what we have just come to again, 1867, in Boxer's new wood fuze.

Another letter from the Committee, nine months later. What happened in the mean time is clear to us, but not recorded at great length, and this is a very different report to the last.

PRESENT.

Lieut.-General Drummond, Major-Generals Lloyd, Blomfield, Colonel Stephens; Lieut.-Colonels Cockburn, Sproule, Borthwick, Burton; Majors Cookson, Riou, Smith, Shrapnel.

WOOLWICH,
March 26, 1804.

Sir,

Be pleased to inform the Honourable Board of Ordnance, that Major Shrapnel having read an account of his experiments for the purpose of ascertaining the causes of some of his shells failing, and bursting in the bores of the pieces of ordnance, has proved to the Committee as well as by experiments tried before them on the 22nd and 23rd instants, that the chief defect was in the fuzes, which he has remedied perfectly to their satisfaction, and they therefore recommend after a proper selection is made of the perfect shells, that General Drummond may be authorized to forward them to the several stations, as adapted to all natures of ordnance.

Major Shrapnel having invented a very ingenious instrument for the purpose of detecting the errors in the casting of his shells, the Committee recommend that several of each may be immediately made to expedite that material part of the service.

He has also improved his fuzes in many essential respects, and the Committee recommend that his process may be adopted without deviation; for which purpose Major Shrapnel will give every communication to the officers of the Royal Laboratory, and will likewise deliver to them the instruments above alluded to.

The Committee in forwarding this report to the Honourable Board, feel themselves also called upon to testify their highest approbation of the uncommon exertions used by Major Shrapnel to discover and remedy any defects either in the construction or mode of fixing his shells, so as to render the invention of which the merit entirely rests with himself of an unquestionable utility to His Majesty's Service.

I have &c.

(Signed) VAUGHAN LLOYD.

R. H. Crew, Esq.

They have paid Shrapnel the compliment of putting him on the Committee. Prospects evidently improving.

On the 5th May, 1805, Shrapnel had the honor of exhibiting his new shells in the presence of the King.

We know that "His Majesty and a great number of experienced General Officers" were present. "In twenty minutes upwards of four thousand shot and splinters," were put into targets in column, to represent mounted men. "No foreigners present."

We can imagine the sight; gratifying doubtless to Shrapnel. What impression was made on the minds of the General Officers no record now extant informs us.

About this time Shrapnel published in the "Gunners Guide, or a Pocket Companion for Non-Commissioned Officers and Privates in the Artillery and Marines" (we did duty in bomb vessels in those days), "Explanation of the advantages and effects which may be derived from firing case shot in the mode proposed by Major Shrapnel. 1803.

(1) The whole charge is carried home to the spot intended; at present the greatest part of the charge disperses soon after it leaves the muzzle of the gun.

(2) Grape or case may be fired with an effect equally close and collected to any distance within the range of the piece, and the artillery need not advance within musket shot of the enemy, to make use of this kind of fire with its full effect, and are not so subject to have their guns charged either by cavalry, or infantry.

(3) It requires less precision and exactness to point a piece of ordnance charged in the manner proposed, than with a round shot, because case shot is a wide and dispersed fire, and the difficulty in elevation is therefore less.

(4) The comparative destruction with that of a round shot, will be generally as the number of shot within the shell to 1; that is, a 3-pr. 20 to 1

in its favour; a 6-pr. 50 to 1; a 12-pr. 108 to 1; a 5½-inch howitzer, or 24-pr. 208 to 1; in which calculation I have not enumerated any effect from the splinters of the shell.

(5) Small balls cannot have so great velocity or be projected to very considerable distances, unless enclosed in a heavy spherical case, which from its form and weight, is not much influenced by the resistance of the air, or diverted from its direction.

(6) The explosion of the shell makes no change in the direction of the shot within it, they consequently complete the shell's track, or curve, which I have sometimes known to be 400 yards: it is not of consequence therefore to be very particular as to the length of the fuze, as it will be cut sufficiently accurate if the shell explodes at any intermediate distance from 10 to 800 ft. short of the object.

(7) I have preferred carbine balls, as they go entirely through a deal target of 2 inches thick, those shot which graze excepted; the fuze hole is made sufficiently large to receive ½lb. shot.

(8) Case shot fired in this manner from mortars would be particularly serviceable in the attack of all field works and intrenchments, as parapets cannot afford any protection.

(9) From the unevenness of ground, such as banks, hillocks, fallow fields, &c., all shot which graze short, most commonly lodge, whereas by using the shell proposed, the whole charge will be carried over those irregularities and reach the object with its full contents of balls.

N.B.—Firing these kinds of shells from guns, is managed with more facility than the ordinary howitzer practice, both as to the length of the fuze, as well as the elevations required, and may be carried on in the field, precisely the same as firing round shot.

These "advantages" are given in another form elsewhere, though the same in substance.

Enumeration of the advantages of Spherical Case Shot.

(1) The fire of artillery is equally severe at all distances.

(2) The whole charge of case shot is conveyed amongst the enemy, even at the greatest ranges, and a fire is produced equally destructive at 2000 yards, as can now be done at 200 yards.

(3) It so simplifies the elevation of ordnance, that such round shot which would miss an enemy by being fired too short, or too high, will when fired as a shell take effect as it terminates in the form of a cone.

(4) There requires no accuracy in cutting the fuze, as it answers very well if the shell explodes 400 yards short of the object, or at any intermediate distance between that and the object, and if the fuze be so long that the shell passes the object, it then acts equally well with a round shot.

(5) This kind of fire is unattainable by any troops that have not a regular laboratory, or cannot get a government supply.

(6) Its effect is such that I have myself put 146 shot entirely through a deal target, two inches thick and nine feet square, at the distance of half a mile, the whole charge being 208 shot, at one discharge.

(Signed) H. SHRAPNEL.

Birch's MSS. in the R.A. Institution :—

Hints on the March—Gunner's Guide.

"Upon the march it is advisable to have all the shells filled with balls, and a temporary or small hand-tap oiled, to keep in order, once a month, the screw at the top of the fuze-hole. Fuzes for short ranges, beginning at 350 yards, to be always kept prepared, cut, and ready in bags, each bag containing fuzes for one range only, beginning at 350 yards, and fuzes kept ready cut for every one hundred yards afterwards, that is 450, 550, 650, 750, and 850 yards, after which distance they may always be prepared in the field, there being plenty of time when the enemy is at a distance, slow firing being then most proper.

"All the balls in spherical case shot, proceed on straight towards the object, in the direction the gun is pointed, and do not fly about when the shell explodes. The splinters of the shells also persevere, tolerably well, in a good direction towards the enemy, from the bursting powder giving them so inconsiderable a lateral velocity in comparison to a forward velocity by the charge from the piece of ordnance."—*Extracted from "Rules laid down by Colonel Shrapnel for Spherical Case Shot Practice."*

Two points of the greatest importance are distinctly asserted in the "advantages" before quoted, (1) a small bursting charge, and (2) the projectile being independent of the irregularities of the ground.

Consequent upon the introduction of this projectile there was a complete change in the system of fuzes then in use. A certain number of lengths of fuze were carried in the limber boxes, distinguished by colours, and suitable for short and medium ranges; for long ranges they had to be specially prepared. In order still further to facilitate the service of these shells, the tangent scales of the guns were marked with the letter of the fuze corresponding to the range, so that the gunner had only to guess his range when both fuze and elevation were shewn him, without troubling him about degrees or minutes, or rates of burning.

Thus, should the gun require an elevation of 4°, G fuze is to be used, the length of which will be $\frac{7}{10}$, and the effect of the balls will extend from 1160 to 1330. (Figs. 1, 2).

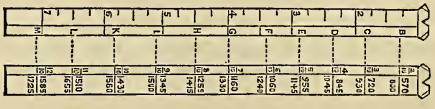


Fig. 1. Flat side.

Fig. 2. Round side.

About half the full size, for a light 6-pr., 5 ft.

The manner of doing business was decidedly irregular in those days. Accounts are queried, and Shrapnel explains as follows, in one breath:—

"I beg to inform you that the Honourable Board had already approved of these journeys being taken, having been pleased to allow me travelling from London to Woolwich to the date of the bill now transmitted for the very same services, which travelling expenses did not terminate in my last contingent bill, as it was necessary to investigate the causes of the spherical common shells giving way, and also to instruct the artillery at Woolwich in the use of this mode of firing from artillery, which was authorized and requested of me to do by General Drummond and Committee of Field Officers, at the time I resided in London to attend Lord Howe as aide-de-camp, and was in consequenee obliged to undertake these journeys.

"With respect to the engraving and printing of my papers upon spherical common shell, I received the Master-General, Lord Moira's, instructions for so doing.

"I have enclosed the copies of two letters to further elucidate the purport of my journeys, one dated the 19th of March, from the Committee, to know if I had finished my experiments, and the other letter, dated March 26, 1804, thanking me for my 'uncommon exertions.'"

H. S.

Shrapnel laboured incessantly to bring his invention to perfection, and partially succeeded. He appears never to have quite overcome the difficulties connected with the transport of loaded shells, for we find recorded in the Annual Register for 1812, that as a company of flying artillery were proceeding to practice near Brighton, three out of four shells exploded. According to the traditions of the old Repository, those who used these shells on service complained of occasional premature bursts, blind shells, and too great a dispersion of bullets; and yet, in spite of these imperfections, and all the uncertainties and doubts connected with a new and practically untried thing, it proved on service to be an invaluable projectile, as we shall shew in the following pages. It was the greatest artillery discovery of the day, and had our enemies possessed it and not we ourselves, the result of many of our battles might have been different to what it was.

We can easily conceive how masses of guns such as Napoleon used crushed everything before them and decided the fate of actions. We have never employed such batteries—why, remains to be explained. The only battle in which, as far as I know, British guns had a preponderance, was at Goojerat, as the following list shews:—

18-prs.	10	8-inch howitzers ...	8
9 "	20	24-pr. " ...	4
6 "	45	12-pr. " ...	9

Total 96.

To these the Sikhs opposed 59 pieces, of which 53 fell into our hands, with all the baggage and stores of the army. This battle will be referred to again.

When judiciously employed, artillery has afforded immeasurable encouragement to the troops with which it has been associated; and ours, even when,

as at Waterloo, numbers and weight of metal were against us, has produced more marked and decided effects upon the enemy than theirs upon us.

It acts in a four-fold manner: the direct loss and the unsteadiness it creates in the enemy, and the transfer of strength, and moral support it gives to its own side. For example, at the battle of Maida, July 4, 1806, the French, full of confidence, quitted a very strong position to attack the British, "and now our artillery began to open with an effect which contrasted strongly with that produced by the enemy's cannonade. In general the French gunners are excellent; they have given us ample reason for allowing this, and we have never denied it; but to day their fire was as worthless as ever came from the merest recruit. Not one shot out of fifty took effect; almost all passing over our first line, and falling short of the second. It was not so with our pieces. Every shot told, and grape, shrapnel, and canister swept away whole sections from the ranks that received it. You all know the effect which is produced upon an infantry line, when it witnesses the able practice of its own artillery * * * and loud and frequent were the plaudits bestowed upon the gallant blue coats who so ably supported them. Nor was this the only circumstance from which our regiments, especially such as had hitherto seen no service, began to draw the most favourable auguries," &c.—*Chelsea Pensioners.*

Again, during Sir David Baird's advance to the attack of General Janssens force at the Cape of Good Hope. "The British must have suffered severely, had the enemy's artillery (to whose fire they were unavoidably much exposed) been better directed." Just the whole gist of the matter. Further reference will be made to this action.

A contrast,—

A prisoner in the castle of St Sebastian, the late gallant General Sir Harry Jones, Royal Engineers, says, describing our artillery practice, "Nothing could surpass the precision with which the shells were thrown, and the accuracy with which the fuzes were cut. It is only those who have had the opportunity of witnessing their fire, and comparing it with that of the French, that can speak of its superiority. When the sound of an English shell was heard in the castle, or when the man stationed on the Donjon called out, *Garde la bombe,* every body was on the alert. The velocity of its flight far exceeded that of the French; touching the ground and bursting were almost simultaneous, and then the havoc and destruction caused by the splinters were tremendous," &c.

Again, "the whole line of light troops commenced a most spirited fire on those of the enemy, who tenaciously contested every hedge and bank that afforded shelter from our fire, and from whence they could take deliberate aim at our men. The artillery posted themselves along the eminences along the whole line, and by a fire of shells greatly aided in dislodging the French tirailleurs from behind the hedges and banks," &c.—*Colonel Batty.*

Perhaps the most marked testimony to the exertions and actions of the artillery on that occasion, Nivelle, Nov. 10, 1813, was given by Sir Howard Douglas when in Committee on the Ordnance estimates, in 1845; he says, "Clausel was strongly posted on a ridge, having the village of Sarre in front, covered by two formidable redoubts, San Barbe, and Grenada. He thought

the country in front was so difficult and impracticable for artillery, that he was astonished when eighteen British guns opened upon the redoubts at daylight in the morning. Under the powerful effect of a shower of shot poured upon San Barbe, the infantry of the fourth division stormed and carried that redoubt. Ross then galloped, he (Sir Howard) begged the Committee to remember the term, galloped, to the rising ground in rear of the other redoubts, drove the enemy from it, when the British infantry, carried it, and the village of Sarre, and advanced to the attack of Clausel's main position. Part of it was carried, but Clausel stood firm, covered by another redoubt, and a powerful battery. These were speedily silenced by Ross' troop of horse artillery, the only battery that had been able to surmount the difficulties of the ground after passing Sarre," &c.

Another account,—

"The result of these splendid operations was the capture of fifty guns, fifteen hundred prisoners, and a considerable quantity of stores and ammunition.

"Though the whole of the allied army conducted itself in a manner impossible to be surpassed, no small portion of the success must be attributed to the artillery under Colonel Dickson. By the indefatigable exertions of that officer, artillery was brought to bear on the enemy's works from situations that appeared utterly inaccessible to that arm."—*Annals of Peninsular Campaigns.*

A cavalry affair, "almost bloodless," Usage, May 26, 1811, reported by Major-General Lumley,—

"A smart cannonade now commenced against superiority of numbers and weight of metal, decidedly in favour of the enemy; but the superior skill and well-directed aim of Captain Lefevre and his Corps (R.H.A.), with only four 6-prs. was most pre-eminently conspicuous. The enemy had thirteen regiments of cavalry in the field. I have the peculiar satisfaction to add, the advantage gained has been almost bloodless on our part, while on the other the enemy suffered visibly from our artillery."

In the operations on the Nivelle, "the artillery," the Duke says, "which was in the field was of great use to us; and I cannot sufficiently acknowledge the intelligence and activity with which it was brought to the point of attack under the directions of Colonel Dickson, over the bad roads through the mountains in this season of the year," Nov. 13, 1813.

These operations are some of the most remarkable the artillery have been ever engaged in—the whole campaign is worthy of close study.

A spectator, Colonel Batty of the Grenadier Guards, describing the action on the Nivelle. "The foot and horse artillery displayed a facility of movement which must have astonished the French; the artillerymen dragging the guns with ropes up steep precipices, or lowering them down to positions from whence they could, with more certain aim pour forth their more fatal volleys against the enemy, &c. Lieut. Colonel Ross' troop of horse artillery, and Lieut.-Colonel Tulloh's Portuguese brigade of guns had also been moved up in aid of the centre, and a most destructive fire was opened against the French on their advance; the havoc caused by their fire on the great road was terrific," &c.

The late Major Macready, describing a charge of the Imperial Guard at Waterloo, says, "They halted and fired, I think badly. We returned the volley, ported, and giving an hurrah! came to the charge. Our surprise was inexpressible, when through the clearing smoke, we saw the backs of the Imperialists flying in a mass. Some guns from the rear of our right poured in grape among them, and the slaughter was dreadful. * * * Whosoever they (the guns) were, they were served most gloriously, and the grand metallic, bang, bang, bang, bang, with the rushing showers of grape which followed, were the most welcome sounds that ever struck my ears—*until*, I married."

The artillery losses alone, at Waterloo, amounted to,

	Officers.	N.C. Officers.	Men.	Horses.
Killed	6	6	74	388
Wounded	30	15	274	123
Missing	—	—	14	35
Total ...	36	21	362	546

The commanding officer of the horse artillery, Sir Augustus Frazer, thus describes a portion of the battle,—

"The earlier hours of the day were chiefly affairs of artillery; but kept down by the admirable and steadily continued fire of our guns * * The howitzer troop came up, and came up handsomely, their very appearance encouraged the remainder of the division of the guards, then lying down to be sheltered from the fire," &c.

"Came up handsomely,"—A thing to be proud of, I think.

To return to our subject.

The first occasion on which the new projectile was applied on service appears to have been on the 31st April, 1804, against the Batavian settlements of Surinam: the British loss was three rank and file killed, five officers, and eight rank and file wounded. The colony fell into our hands. The official accounts state that "after a few shells from two mortars which we had got on shore, the firing on the part of the enemy ceased."—*Annual Register.*

Major William Wilson, Commandant of the Artillery, who is thanked for his services, states the matter somewhat differently, however. He says, "Shrapnel had so excellent an effect, as to cause the garrison of Fort Amsterdam to surrender at discretion after receiving the second shell. The enemy were so astonished at these shells as not to be able to account how they apparently suffered from musketry, at so great a distance as 2050 yards."

A very respectable range indeed, and very astonishing to the enemy, no doubt.

We now turn to the operations at the Cape of Good Hope, under Sir David Baird. His army consisted of 6600 men, including 320 artillery and artificers. By the wreck of a transport, Brigadier-General Yorke, Commandant of Artillery was drowned, and the command of that arm devolved upon Major Spicer. After considerable trouble in disembarking, on account of the surf, the army, about 4000 strong, moved forward, and attacked the enemy in

the plains of Blueberg, formed in two lines, having, "sixteen 8-prs. in the first line, and seven in reserve. We had two 5½-inch howitzers, and four 6-prs."

"The left brigade, Highland, under General Furgusson, advanced rapidly under a heavy fire of cannon and infantry from their lines of infantry, which broke at the moment the British were preparing to charge."—*Official Report.*

One hundred and ninety were killed and wounded on our side, the enemy lost upwards of 700. Artillery details are given here, in a letter from Major Spicer, himself,—

CASTLE, CAPE OF GOOD HOPE,
18th August, 1806.

"The excellent effects of the spherical case shot drove the enemy from their guns, and the left of General Janssens' line, opposed to our right, which fired spherical case shot only, was the first to give way. General Janssens expressed his astonishment to Sir David Baird that his Waldeckers, whom he thought he could depend upon, should so soon break; but it originated in consequence of so many of his men being wounded by musket balls, when no infantry were within range of them."

Even *Waldeckers* are not to be depended on. High time to give up the Cape! "Spherical case shot only."

General Furgusson, some years afterwards, stated with reference to this affair,—

RAITH, FIFESHIRE, NEW BRUNSWICK,
19th August, 1816.

"* * * But, from the reports of the enemy the spherical balls did great execution, several of the enemy's guns opened a fire of grape and canister at a distance where it could have no effect. They saw their mistake, and again fired round shot until we advanced nearer to them. From this it is obvious, the spherical shells had reached the enemy, who mistook it for grape, and endeavoured to return it without effect," &c.

Young soldiers are generally inclined to magnify the dangers of their first engagement. Not so Lieutenant F. Graham, R.A. who writes to his father,—

TABLE BAY, CAPE OF GOOD HOPE,
14th October, 1806.

"This place was taken with very little difficulty; the battle lasted only half an hour. As soon as the English began to exercise the new invented shells, the enemy fled into the mountains, and left the English army to take possession of the town."

Now for the Dutch commander's account of the transaction—very curious, interesting, and instructive.

After describing the disposition of his forces, cavalry, infantry, artillery, and marine brigade of French sailors, he says, "At five o'clock the enemy attacked the left wing * * * They brought six field pieces against us, and at first their howitzers were directed principally to our centre, where the General stood, a few paces before the line with his staff * * * One of the first howitzers struck the right of Waldeck, which created more confusion than the General could have supposed. More howitzers fell into

that corps, and the soldiers did not appear to answer the opinion which might be expected of them, from their general known conduct, and particularly in the campaign of 1794 * * * *

"A fine and numerous Scotch corps advanced in front of our small number of infantry, and discharged a full round, but it being at too great a distance, few, or none of them (i.e. ours) were wounded. This was a fortunate circumstance, according to the plan the General had formed from the beginning, which was to wait until the enemy had approached within a few paces and then to fire a tremendous round from our side; but the Waldeck battalion retreated in confusion. He rode up to them, conjuring them by their former glory, by their beloved Prince, and by everything he could say, to stand and shew they were brave soldiers; but neither this, nor the request of their officers had any effect, they most shamefully fled. After the battle, the General saw with pain the remains of the Waldeck battalion of whom he had formerly had so good an opinion * * * He conceived that he ought not to shew any weakness, and therefore ordered that corps, with an indignation denoting what had happened, to march to town immediately," &c.

"J. W. JANSSENS."

"Castle of Good Hope,
"27th January, 1806."

The next day, the town, which was regularly fortified, and armed with one hundred and fifty heavy guns, surrendered to less than 4000 men and a few pieces of light artillery, and the colony was won.

The unfortunate Waldeckers were first chastised by our "howitzers," and then dismissed in disgrace to the town, to "encourage the others," which they did so effectually, that as soon as we began to "exercise the new invented shells," no further resistance was offered.

In the public dispatch, announcing the battle and acquisition of the colony, the services of the Royal Artillery are not even once mentioned, and the only allusion to their presence is as follows :—

"Herewith I have the honor to enclose for your Lordships information, a return of the ordnance found in the citadel and other defences of the settlement, but which is perhaps inaccurate, for the reason assigned by the Commanding Officer of Artiltery.

"I have, &c.

"To the Right Honourable
Lord Viscount Castlereagh."

"(Signed) D. BAIRD."

It might have been supposed, after what has been just described, that the invention would have met with some degree of favour with the authorities; quite the reverse : it was saved from oblivion chiefly by the exertions of the late Sir John Sinclair, Bart. His son says, p. 243, Vol. II., Memoirs, "It will appear from the above quotation, that my father insisted earnestly on the necessity for providing our army with the most effective military weapons. He was the more anxious on this point, both because our Board of Ordnance, in a very important instance, had recently shewn a degree of negligence disgraceful to themselves and disastrous to the country; and

because he was at that time labouring to bring forward an ingenious invention, of which all his efforts could not induce them to avail themselves. * * * * It was a kind of shell invented by an ingenious officer of artillery, Lieutenant-Colonel Shrapnel, and now familiarly known by the name of *spherical case shot.* * * Like other projectors of genius, he was rather an enthusiast, and by the strong expressions he employed in setting forth the merit of his new plan, provoked scepticism without awakening interest. * * By his vehement and importunate zeal, he irritated old officers, who in their attachment to established usage, branded him as a mere innovator, and declared their conviction, that his schemes however plausible in theory, would utterly fail in actual service. * * *

"I have a vivid and painful sense of the difficulties encountered by my father in bringing forward and calling into general use this new instrument of war, from the vast magazine of papers connected with the subject, which it has been my province to examine and reduce to order. * * *

"In consequence of conversing and corresponding frequently with this ingenious and sanguine officer, and of hearing from him all his hopes and fears, encouragements and disquietudes, the Baronet became enthusiastic in his support, and, more than half in earnest, used to designate Shrapnel 'the modern Archimedes.'

"As the most effectual means of rousing the Board of Ordnance, Sir John proposed in 1807, to bring the subject before Parliament; but no sooner did he inform the Colonel of his intention than the latter with patriotic earnestness, entreated him to desist. 'I am anxious,' he writes, 'that the invention should not be made public in any way, lest its importance should thus be signified to the enemy.'

"General Lord Suffolk took up the cause with great zeal; and in a letter dated Hastings, 19th July, 1808, thus describes two interviews with Mr Canning upon the subject:—'I carried with me one of Colonel Shrapnel's engraved plans of the effect of his shells, with which Mr Canning appeared to be much struck, and informed him such was their utility, no officer now commanding an expedition would sail without them. * * * Mr Canning took some notes on the subject, and as the Cabinet appears to have acted upon some of the principles then stated, I trust this communication was not entirely without effect.'

"But my father's hopes rested chiefly upon Mr Percival, to whom he frequently addressed the most urgent applications upon the subject. 'I entreat you,' he says, 'by everything you hold dear and valuable, as a man, as a father, and as a British statesman, to bring this subject before the Cabinet. * * * Do justice to the inventions of Shrapnel and you may yet save Spain and Portugal, and make this country impregnable.' * * *

"A question here arises, has the country shewn a proper sense of gratitude for the services of Colonel Shrapnel?"

We now come to a remarkable action, reminding us of what happened before in India, in which infantry and artillery gained a complete victory over "the three arms" combined, Maida. Here bayonets were crossed, as is asserted, for the first time.

In 1806, the Calabrians rose in revolt against the French, and we sent 5000 men from Sicily to their aid. On the 6th July, 7500 men under Regnier, of whom 500 cavalry, and two batteries horse artillery encountered 4500 British under General Graham, with two howitzers, and four light 6-prs.

A spectator, Sir Sidney Smith, says, "The artillery in the British line was particularly well served, and it was evident the shell of Colonel Shrapnel's invention when burst in flight and short of their objects as they ought to be, did great execution," &c.

Gunner R. Marshall, who was with Lieutenant Dynely's guns, says these shells "were used with the greatest effect, particularly from Captain Pym's guns. The French cavalry went to the right about and retreated," &c.

The General in his dispatch, says, *generously*, "the judgment and effect with which our artillery was directed by Major Lemoine was, in our dearth of cavalry, of most essential use, and I have a pleasure in reporting the effective services of that valuable and distinguished corps," &c.

The British losses were,—

	Officers.	Serjeants.	Rank and file.
Killed	1	3	41
Wounded	11	8	261

The total loss of the French was about 4000, and the stores of the army fell into the hands of the Calabrese.

What renders this action peculiarly interesting to the student is the overweening confidence of the French in their numbers, and constitution, (cavalry, infantry, and artillery), leaving their strong defensive position, to attack us; their complete overthrow, the use made of our artillery, and the handsome manner—very unusual—in which the General acknowledged their services.

Sir Sydney's remark, "burst in flight and short of their object," is worth remembering.

Three feeble and fruitless expeditions were undertaken this year, namely, against, Constantinople, Egypt, and Buenos Ayres. With regard to Egypt, *Miles*, who writes in the United Service Magazine, states, "The enemy's cavalry made use of their fire-arms, but after the experience of Shrapnels seemed cautious, with the exception of excited chiefs or drunkards who flourished their sabres and caracoled their horses; and these horsemen constantly formed in advance of their main body. * * * When the cavalry approached the artillery made excellent practice, and the effects of shrapnel (6-prs.) seemed to astonish * * *

"I do not know whether the shrapnel shell may or may not be esteemed an efficient projectile by competent authorities. I have heard that the Duke of Wellington thinks lightly of it; but this I know, that it was the only sort of missile which had the smallest influence in delivering us from the presence of these troublesome neighbours."

After the surrender of the remainder of the force, the writer, describing the interview with the vizier, says,—

"Pipes and coffee were now introduced, while the vizier continued to question us closely as to the details of our military system; appearing

particularly anxious to know how our regiments were constituted, of how many men each consisted, and in what proportion it was officered. The effect of the shrapnel shells too had astonished him, and he expressed great anxiety to be informed of their composition; but on this head we were content to inform him only, that they contained musket balls. He answered sharply that he knew that very well," &c.

The writer (an infantry officer), speaks highly of the exertions and skill of Lieut. Dunn, R.A. who commanded the guns.

In 1807 the Copenhagen expedition was sent out to demand the Danish fleet "in deposit." A large body of militia and regular troops were assembled at Kioge to oppose the British force, in march upon Copenhagen, under Sir Arthur Wellesley.

Lieutenant John Wilson, R.A., states what he witnessed of the use of the shrapnel on that occasion,—"The chief part of the Danish army was formed in two close columns, with fourteen pieces of cannon. They were cannonaded for near half an hour from four guns and two howitzers, at about 500 yards distance, served with your (shrapnels) shells.

"The consequence was the complete breaking of those columns; they dispersed, throwing away their arms," &c.

Copenhagen was then bombarded, and the Danish fleet carried off, to the indignation of Europe, but the satisfaction of England.

Sir Arthur attacked in echellon of battalions from the left, covered by the first battalion of the 95th and the artillery. * * * Sixty officers and 1100 men were made prisoners. The British artillery under Captain Newhouse, and the Hanoverians under Captain Sympher, were favourably mentioned in the dispatch.

It is worthy of remark that great doubts existed on the British side as to the nationality of a body of troops near them, on account of the red coats with which they (i.e. the Danes) were clad. This circumstance caused great delay in commencing the action; the artillery fire was opened at a very short distance, and the enemy broke, or surrendered before any great loss was inflicted upon them.

These victories have been very decided, but comparatively bloodless: we now turn to more serious work, the Peninsula War, "Whilst waiting for a wind at Portsmouth," Shrapnel, at the solicitation of Lieut.-Colonel Robe, the commander of the artillery of the expedition, equipped him "in the way he should himself recommend for taking the field," with six "lengths" of fuzes, tin boxes, and canvas bags.

We shall presently see the result of this arrangement. It was fortunate for us that the wind was foul on that occasion.

Roliça. "The enemy's loss has been very great, and he left three pieces of cannon in our hands." Battle offensive on our part.

The next, Vimiera, was defensive; both actions very glorious to us. At Vimiera, "the enemy sustained a signal defeat, lost 13 guns, 20 ammunition wagons," (*Dispatch*), and about "2000 killed and wounded, and 400 prisoners."—*Alison.*

The following letters relate to those two actions. The first from Sir Arthur to Sir John Sinclair,—

HOLYHEAD,
October 18, 1808.

Dear Sir,

I have had the pleasure of receiving your two letters, and I am much concerned that I was not at home when Lieut.-Colonel Shrapnel did me the favour to call upon me in London. I shall have great pleasure in testifying at any time the great benefit which the army lately under my command derived from the use of spherical case shot in two actions with the enemy—a benefit which, I am convinced will be enjoyed, whenever they will be judiciously and skilfully used.

I consider it however, to be very desirable that this invention, and the use which the British have made of it should not be made public. Our enemies are not aware of the cause of the effect of our artillery, of which they have complained; and we may depend upon it, that any public mention or notice of the benefit we have derived from this description of shot would induce them immediately to adopt it.

At the same time I consider Colonel Shrapnel to be entitled to a reward for his ingenuity, and the science he has proved he possesses by the perfection to which he has brought this invention; and more particularly so, because I am of opinion that the public interests require that the advantage which we have derived from the use of the shot should not be made public, and he be thus deprived of the fame and honor which he would have enjoyed * * *

I have the honor to be, &c.,

ARTHUR WELLESLEY.

The next is to Colonel Shrapnel:—

ABRANTES,
June 16, 1809.

I have the satisfaction to acquaint you that the spherical case shot were used by the artillery with the army under my command last year in Portugal, and I have every reason to believe that they had the best effect in producing the defeat of the enemy at Vimiera, on the 21st August, 1808.

ARTHUR WELLESLEY.

From Sir John Sinclair to Colonel Shrapnel:—

My dear Sir,

As *the crisis* is so fast approaching, I am making every exertion I can possibly think of to bring your shot into more general use. You will have received a copy of Sir Arthur Wellesley's letter to me. I have written an answer, a copy of which I enclose. I have also written to Mr Percival on the subject of a public reward to which you are so justly entitled * * * What can I do more?

(Signed) JOHN SINCLAIR.

CHARLOTTE SQUARE, EDINBURGH,
November 15, 1808.

From Sir John Sinclair to the Marquis of Wellesley:—

My dear Lord,

I have long had particular access to know the infinite importance of Colonel Shrapnel's spherical case shot, which is fully confirmed by a letter I had the pleasure of receiving the other day from Sir Arthur Wellesley.

It is a certain fact that our allies the Spaniards have not the least idea of this most important discovery, though they are now about to be attacked by such formidable armies; and it is still more unfortunate that no spherical case shot was sent with Sir David Baird's army, now about to face the enemy.

I need not dwell on such a subject to an enlightened statesman, and to a real patriot. I have only to request, that after seeing Sir Arthur on the subject you will exert all your influence with Lord Chatham to prevail on him to hurry off as much of the case shot, as possible, with an energy such as his father would have exhibited on such an occasion. The fate of Spain, of England, and of Europe *may depend* on the celerity with which this is accomplished.

I have, &c.

JOHN SINCLAIR.

CHARLOTTE SQUARE, EDINBURGH,
November 15, 1808.

Private official, from Colonel Robe, commanding Royal Artillery to the Honourable Board, August 25, 1808:—"After the result of two actions which have taken place between this army and the French on the 17th and 21st inst., it becomes my duty to notice to you the very excellent effects of Lieut.-Colonel Shrapnel's spherical case shot, seen and acknowledged by every general officer in this army, and even by those of the enemy, and I have Lieut.-General Sir A. Wellesley's authority to express to you his entire approbation of it.

"It is also incumbent upon me to acknowledge that Lieut.-Colonel Shrapnel's method of classing his fuzes in boxes for different ranges was entirely adopted by me, and to that is attributed the quickness and precision with which that sort of ammunition can be made use of in action."

And again:—Camp near Torres Vedras, August 25, 1808, "The artillery has been highly complimented, both by the French and all our own general officers, in a way highly flattering to us; and I should not do my duty to the service, were I not to attribute this good fortune to a good use of that weapon with which you have furnished us. I told Sir Arthur Wellesley I intended to write to you, and asked if it might be with his concurrence: his answer was, 'You may say anything you please, you cannot say too much.'"

Here is testimony from Lieut.-Colonel Landman, commanding Royal Engineers at Roliça:—"The French left about 150 dead on the field, many of them having three or four musket or carbine balls in their bodies, which could only have been caused by the spherical case shot invented by Colonel Shrapnel, R.A. This was the first field action in which they were employed, and certainly with wonderful success."*

Of Vimiera he adds:—"Spherical case shot was here used with prodigious effect, especially against the close column advancing to the attack. * * * The enemy, upwards of 5000 men, not having antici-

* The Lieut.-Colonel was mistaken in supposing that they had not been used before.

pated such a warm reception, and having lost a vast number of men, principally by the spherical canister shot, suddenly as if by an order turned about, and every one for himself, ran off down the hill in a confused troop," &c.

He adds, "Captain Elliott, of the Royal Artillery, caused a corps of cavalry to change direction by firing a few rounds of shrapnel from a 9-pr., although at the distance of about 1800 yards, he being stationed on the right of the second line," &c.

The French General, Foy, who was in the beaten army at Vimiera, has the following:—"Dix huit pièces de cannon tiraient à la fois, et leur boulets creux emportaient de leur premier jet les files d'un peloton pour éclater ensuite, comme obus, dans le peloton suivant, l'artillerie de la première division, et de la reserve respondait faiblement à ce feu," &c.

The General was evidently astonished at the new British projectile, and quite unable to account for the effect produced by it.

Sir Roderick Murchison writes:—16, Belgrave Square, January 30, 1867, "We had not been long in line, partly under the slope of a hill, with a moory plateau beyond us to the north, when a rattling force of close columns of six battalions of the enemy with a battery of artillery, came across the heath of Sourinha, whilst the men of our Brigade, 36th, 40th, and 71st, lay on their breasts, ready to rise when called upon.

"It was during these fifteen or twenty minutes, that the shrapnel shells fired against an advancing enemy took such deadly effect. Two guns served by Lieutenant Locke, were so admirably managed—the fuzes being so justly manipulated by the fine eye of that officer—that every horizontal shell burst in the centre of one of the serried masses, who thought they were carrying everything before them, and were shouting 'Vive l'Empereur!' But still they pressed on, and when, our skirmishers falling back, their columns were close on us, Fergusson waved his hat and we sprung up, and with our then well polished firelocks glittering under a fierce sun, we went at them in the steadiest and most methodical line, and without firing a shot, but with a loud hurrah!

"The effect was electric! The French fled with a 'sauve qui pent.' We took all their guns, and after chasing them over the heath for a mile we captured their brave General, Solignac, &c. * * * The prisoners we took, and they were numerous, said, 'Mais, que diable y avait—il dans vos boulets?' It was this beautiful artillery practice, and our brilliant attack, that led me to hold as a dogma the value of such a system for English troops in all practicable cases; and hence I have ever since sworn by a shrapnel shell when served by a man with a fine eye, and cool head.

"I do not mean to say that shrapnel shells were not fired at Vimiera by other officers than Lieutenant Locke, but I am sure, from the sudden and close attack on our centre, and the interposition of woods and undulations, there was no such *opportunity* for making each shell tell with unerring effect, as when the enemy's close columns were advancing over a flat plateau-heath."

The proportion of shrapnel in those days was only 9 in the 100 rounds. Colonel—afterwards Lord Hardinge—applied immediately for a large proportion.

A glimpse of the retreat to Corunna.

Corporal John Lomax, 7th Hussars, writes to his sister:—"The French formed on the other side of the water: we brought two guns to bear on them with *spiritual* case shot, which laid some of them low, and made the others go over the hills which were close by."—*U.S. Magazine.*

Another reference to this affair:—"The French formed again on the other side, and threatened a second attempt; but three pieces of horse artillery which now came up, were stationed near the bridge, and opened a fire upon them which did considerable execution," &c.—*Southey.*

And in describing the battle of Corunna, Southey says,—"Our artillery was embarked, and the shrapnel shells which contributed so materially to the success at Vimiera were not used in this more perilous engagement," &c.

Talavera. In this stiff, defensive, two days battle, against more than double our numbers, "the artillery," the Duke reported "were of the greatest service."

Napier says that, "Eighty pieces of French artillery sent a tempest before the light troops. * * * The Spanish troops were not in a state of discipline to attempt a manœuvre," or ——? Our losses were 6268, those of the French 7389, and 20 guns.

In his "Defence of Portugal," Captain Elliot, R.A., says, "Eighteen pieces of cannon which Colonel Robe, of the Royal Artillery had formed in an oblique direction were brought to bear on the flank of the enemy's column, and occasioned great destruction by the fire of spherical case shot, or Colonel Shrapnel's shells, both as they advanced, and when they had retreated beyond the range of musketry."

Jomini was kind enough to state that this battle at once restored the reputation of the British army!

After a lapse of two years Sir William Robe writes again, giving a summary of his experience, and shewing his confidence in the projectile by having recommended *a larger proportion.*

His brief remarks on the passage of the Douro,—a wide and rapid river,—in face of the enemy, are instructive and interesting. The operation, one of "consummate ability," should be studied in Sir Howard Douglas' work. The French lost on that occasion five hundred killed or wounded, five guns taken in the fight, and fifty in the arsenal.

"The brave 3rd Regiment," now the Buffs, were ferried over and posted in a convent under our guns.

VEZEU, PORTUGAL, March 31, 1810.

"I now write as an old friend, convinced of the efficacy of the weapon, when properly applied; and considering its character as established, wish that it may be used with as little deviation from its original simplicity as possible.

"After Vimiera, a much larger proportion of the spherical case was recommended and allowed.

"At Oporto we were situated so as clearly to discern their effect on the troops opposed to the brave 3rd Regiment, who acknowledged the service they received.

"At Talavera, I happened to be immediately placed with the long 6-pr.

Brigade, and on an eminence where we could observe them, as well from our own guns, as from the two brigades in the centre, where Col. Framingham was; I shall only repeat my satisfaction at their effects."

Here is *one* good round against artillery, described by Lt. Robe, R.A.:—Sabugal, April 4, 1811, "We had two guns brought up with the light troops, commanded by Captain Ramsey and Lieut. Stanhope; they were particularly well served, and by one spherical case shot, killed or wounded all the men at a howitzer the enemy brought against them," &c.

Barossa was a glorious action:—March 7, 1811, "The army countermarched with an alacrity which served as a favourable omen. But in such intricate and difficult ground, order could not be preserved. Major Duncan soon opened a powerful battery of ten guns in the centre. As soon as the infantry was hastily got together the guns advanced to a more favourable position. An eagle and six guns were taken (Napier) and upwards of 3000 men killed, wounded, or prisoners."

Lieut. T. O. Cator, R.A., shall speak first,—"Shrapnel's shells laid them in heaps. I went over the field next morning and saw them lying in heaps, and some of the poor wounded have five or six balls in them," &c.

Major Duncan, who commanded the artillery states:—Isla Cadiz, March 6, 1811, "We yesterday fought a most glorious action, the details of which the dispatch will better inform you. Lieut. Woolcome is the only officer of ours killed, but seven wounded, and a great proportion of men and horses. Pray thank Colonel Shrapnel from me for his spherical case shot, they did wonders."

The late General Sir Robert Gardiner, K.C.B., wrote: "In the battle of Barrosa the whole of the British artillery were massed in advance to cover the deployment of our columns. During the deployment the enemy was advancing in line, his front covered by numerous riflemen and light troops, but at too great a distance for our employment of grape or canister. The shrapnel here was most advantageously employed and did great execution."

This is remarkable evidence: even "riflemen and light troops,"—skirmishers in extended order cannot escape.

Quarter-master Surtees of the Rifle Brigade says of this battle, "I never witnessed any field so thickly strewed with dead as this plain was after the action; about 4000 in the two armies in about an hour and a half."

General Graham in his Barrosa dispatch says, "I owe too much to Major Duncan and the officers and corps of the Royal Artillery, not to mention them in terms of the highest approbation; never was artillery better served."

The next is from Sir Augustus Frazer, always ready to serve his country,—

WOODBRIDGE,
March 5, 1811.

My dear Shrapnel,

I have accidentally heard that you have been enquiring for a convenient range of 2000 yards in the neighbourhood of Languard Fort, and that you are desirous that the range should be free from shingle and mud. Sutton Heath comprises these advantages, and indeed many others for practice or experiments of any kind; and it would afford me very great pleasure that any experiments you may be making should be tried there. If secrecy be an object nothing can be more retired,

and as we are in expectation of orders to form the Board to carry on a course of mortar practice early in the spring, any article or those necessary for any other practice will necessarily be at hand. The mouth of the river Debin (four miles from Sutton Heath) affords a good point to land stores at; with our horse artillery draft horses there is every facility to forward ordnance and stores to the place of practice.

I have been very desirous of having mortar practice, of which I have seen none yet on a scale of anything like sufficient magnitude.

I think you mentioned to me some time since, that you had been trying on Marlborough Downs a mortar with a parabolic chamber, and that it had ranged much beyond those in general use. I should be glad to hear any particulars you will favour me with, respecting this mortar, or any other improvement you may have lately made in our arm.

In case you would commit to our care the carrying on any experiments, you may depend on the greatest care and conformity to any instructions which you may give. I write in great haste to save the post.

Yours sincerely,
(Signed) AUG. S. FRAZER.

There is a longer range on Sutton Heath than the French range at Cadiz.

Patterns not yet settled, says Lieutenant J. Sinclair, R.A.

Head Quarters, St Vincents, near Elvas, July 4, 1811, "I gave your paper to Major May to read, and several of the captains have taken copies of it. The Major says that neither your new shells nor white fuzes ever came to hand. * * *

"I have since learnt that the case shot was used both at Fuente d'honor and Albuera with the greatest effect."

One feels sorry that *all* the captains did not take copies of "it." Perhaps they might have done more good had they done so. "White fuzes" I know nothing about.

Albuera was one of the toughest fights we have ever fought. May, 1811. The French under Soult placed fifteen thousand men and thirty guns within ten minutes march of Beresford's right wing. A feint attack in front, a real attack on the right, and Beresford had to change front to the right. No encouraging alacrity this time on the part of our allies. But the French column never deployed! an enormous unwieldly mass. Southey, the historian, says (authority not given), "that the French at Albuera suffered much from shrapnel during their retreat."

Napier says, "The British had no trophy to boast of, but the horrid piles of carcasses within their lines told with dreadful eloquence who were the conquerors." The loss of the allies was about 7000 men, of the French about 9000.—*Annals.*

A cavalry combat. Captain E. C. Cocks, 16th Dragoons, 6th July, 1810, says, "Our artillery were served very well, and with considerable effect. I saw several shrapnels burst in the middle of the enemy's squadron," &c.

At the passage of the Tordesillas, July 2, 1812, the enemy's rear guard, composed of infantry and cavalry, was attacked by our horse artillery. Surtees says, "Some of our horse artillery came up and fired shrapnel shells into it, which did considerable execution; our shell particularly having killed and wounded great numbers, among whom was an officer, I think one of the handsomest men I have ever seen," &c.

There was no fear of firing over your friends' heads. General William Napier, in describing the retreat from Salamanca, 1812, says, "Nevertheless, by giving a quick and well sustained fire, and then running down before the smoke cleared away, we gained the fords in safety. Ross' guns fired shrapnel shells over our heads as we descended, and thus kept the enemy in check," &c.

At *Busaco*, another defensive battle, Sir John May writes, "They (the shells) were of the utmost use, and their destruction very plainly perceived from the heights," &c.

This battle, says Belmas, made Massena "more circumspect." Their losses, according to Napier, were about 4500 men, the allies 1300.

Sir Henry Torrens, Adjutant-General to the Forces, thus writes; speaks well out; no hesitation; Horse Guards, 5th March, 1812, "I have seen this destructive arm used with great effect against the enemy in the battle of Roliça and Vimiera, in Portugal: in the latter action I have no hesitation in attributing the success of our arms, to the amazing impression made upon his ranks by the spherical shot," &c.

Is it useful against boats?

Major Nicolls, Royal Marines, writes:—Woolwich, March 16, 1812, "Sir Richard Keats would have had a severe drubbing in the Great Belt, but for them. The first shells he fired at the gun-boats they scampered off * * * I knew from the Danish officers that they could not get their people to stay at their oars, when the shells were fired," &c.

Penzance experiments progressing favourably.

PENZANCE,
December 14, 1812.

Sir

It is with great satisfaction I have the honor to state for the information of the Master-General and Honourable Board that I have proceeded with the experiments at this place, which have succeeded admirably well, and from which the service will derive most essential advantage.

The first object in view was to give greater velocities to the shot within the shells which I have accomplished, and at the same time have effected a more simple manner of using this new system of fire, which I make no doubt will be esteemed of some importance.

The charges of powder are now so adjusted that the same fuze will suit every kind of brass gun without varying the degree of elevation, which introduces a material simplicity in the pointing of cannon.

I have also adopted a new method of priming fuzes without quickmatch, and I consider this alteration an improvement of consequence, because quickmatch is very liable to get damaged, and also to lose the composition which should adhere to it; in either of which instance ignition cannot take place, and the shell can only act in such case as a round shot. I have fired several hundred of them with great certainty. These fuzes are made more expeditiously and at a less expense than those now in the service.

In the construction of these tables I have been obliged to well ascertain the following particulars, viz.:

(1) The elevation of the ordnance.

(2) The length of fuze.

(3) The time the fuze has burnt (which I have taken to the 40th of a second) during the passage of the shell in the air.

(4) The distance the shell explodes from the ordnance.

(5) The height it explodes above the piece.

(6) The angle of elevation it explodes above the object from the piece of ordnance.

(7) The initial velocities of the shell in a resisting medium, or during its passage through the air in each second of time.

(8) The first graze of the cone of the shot.

(9) The point where the greatest effect of the charge takes place.

(10) The extreme grazes of the cone of the balls.

An accurate attention to all these particulars was necessary in order to establish a perfect agreement and combine the whole in one system; and it is requisite here to observe that the present equipment of these shells which has been issued is by no means correct. I expected by this time to have completed the guns and howitzers at this place, which are all in a great state of forwardness, and if the weather proves favourable will soon be finished.

I have the honor to be,
&c., &c., &c.,
HENRY SHRAPNEL,
Lieut.-Colonel, Royal Artillery.

R. H. Crew, Esq.,
&c., &c., &c.

Is shrapnel applicable to covering debarkations?

Sir Sidney Smith says, "I used them with effect in the dispersion of the Asiatic troops, who in vain attempted to oppose the landing of the boats of the division at the Dardanelles, February, 1807."

Allen's account is:—"As the redoubt continued its fire upon the British ships, Sir Sidney turned his fire in that direction, and a few shells judiciously thrown dispersed the Asiatic troops; Lieut. Mark Oats with the Pompées' marines landed and took possession of their standard, &c. * * * Eight of the large guns were spiked." We may mention, in passing, that on the return of the squadron, the Turks fired at them, some of the shot weighing 800 lbs., and causing a total loss of 46 killed and 235 wounded. Lucky for the squadron these large guns were wretchedly mounted, and laid *beforehand.*

Here is a letter from Sir Sidney, in despair:—

HIBERNIA, PORT MAHON, March 9, 1813.

"Despairing of being indulged with a supply of your spherical case shot, by an official application, I beg the favour of you to procure me from Carron 200 with screw orifices and fuzes for the 6-prs., &c."

How the Board managed their business in those days is not clear to us. We can only hope the gallant admiral obtained the stores he wished for without having to pay for them out of his own pocket.

We have once more to chronicle the defeat of General Janssens. This time the scene is in Java, of which colony he had been appointed governor and commander-in-chief by Napoleon. In taking leave the Emperor said to him, (one sympathizes with him), "Souvenez vous monsieur, qu'un General François ne se laisse pas prendre une seconde fois."

On the 4th August, 1811, the British force intended for its conquest arrived in the Bay of Batavia, on the 10th the advance drove the enemy from his first position. There were with the advance two guns of the horse artillery under Captain Noble. "I cannot say too much of Captain Noble and the officers and men under his command, who so gallantly fought the two guns that drew a most terrible fire from the enemy; indeed, the zeal and ability displayed by Captain Noble throughout this service demand my particular attention."—*Col. Gillespie's Dispatch.*

The enemy then retired to a strong fortified camp, Maister Cornelliis, mounting 280 guns. Heavy guns were landed from our ships, batteries were formed and the place was attacked. Captain Napier, R.A., commanded the batteries. "Ou ne tarda pas à s'apercevoir que l'artillerie française quoique supérieure en nombre à celle des Anglais, était moins bien servie que celle-ci. Le feu des redotes fut étaint à pleusieurs reprises, les batteries endommagées, et vers le soir pleusieurs pièces se trouvèrent démontées."—*French account of the Defence.*

On the 26th August the camp was assaulted and taken, though with heavy loss,—11 officers killed, 47 wounded, on our side.

The enemy's losses were about 1000 killed in the camp, great numbers outside, 6000 prisoners, 263 brass guns and mortars, and 504 iron guns.

Janssens made another stand just beyond Samerang, with no better success. The operation is described in the following extract from the General's dispatch:—

"The enemy retired to a strong position, with a force of 8000 men, cavalry, infantry, and artillery; his batteries and intrenchments are completed in a pass of the hills. The British force consisted of 1100 infantry, four 6-prs. under , and some pioneers. As the leading detachment moved forward to turn the enemy's left, a fire was opened upon them with many guns, answered by our field pieces, with the effect, though fired from a considerable distance, and with great elevation, of confusing the enemy's artillery in directing their fire. * * * The enemy abandoned the greatest part of their artillery, and were seen in great numbers and in great confusion in full retreat," &c.

Our loss was two killed, and a few wounded.

Early in the night General Janssens sent in a flag of truce. His force had been 8200 men and thirty guns!

The Adjutant's-General's (P. A. Agnew's) letter, which comes next, shews in a satisfactory manner how the latter victories were won:—

"The spherical case shot were used against the position of the enemy at Maister Cornelliis with very considerable effect, at various distances.

"In the attack of the enemy's position on the heights of Gattee Ali, they were eminently useful. Though fired at a great elevation and long range, the enemy were after a few rounds driven from their batteries, which they abandoned before the troops ordered to attack them could descend the hill to come at all in contact with them. * * * Other shot were very seldom used."

He also adds:—"Various experiments at the several Presidencies in India had convinced the military authorities there, and particular orders were given for a large proportion of this kind of ammunition to accompany the expedition; 100 rounds of spherical case shot were sent with each field

gun, and as many as could be procured with the heavy artillery; but of this sort the stores could not supply sufficient."

It would then appear from this, that the new projectile met with more favour in India than at home.

Complaints,—

"A concise account of the causes which have brought Lieut.-Colonel Shrapnel's spherical case shot into disrepute.

"The misapplication of spherical case shot proceeds in the first instance from the want of a proper range being obtained for artillery practice at Woolwich to form the judgment of the young officers who now often fire that ammunition at ranges which are beyond their power, or too short; consequently, in the first case, the lead bullets leave the spherical case when it has not a sufficient velocity to give these bullets the required force, and in the second case the shell bursts in the gun for want of a proper body of fuze composition to bear the shock of the piece.

"Precautions which will probably prevent any further misapplication of the spherical case shot.

"(1) The spherical case shot should be carried in a carriage distinct from the other ammunition of the brigades of field artillery as His Royal Highness the Commander-in-Chief formerly ordered.

"(2) Two intelligent artillerymen should be attached to each wagon load of spherical case shot to take charge of it.

"(3) If spherical case shot is required to be used in very long ranges, they should be attached to the Congreve rockets, because the velocity of their flight will then increase as the squares of the times that the composition of the rocket burns, whereas shot from cannon at low angles lose their velocities as the squares of the times of their continuance in the air.

"Note.—It is certain that the enemy has often suffered from a proper application of Colonel Shrapnel's spherical case shot, as proved by the testimony of Lieut.-Colonel Robe, and Lieut.-Colonel Duncan of the British artillery."

Author unknown, probably Colonel Williamson, formerly superintendent Royal Military Repository. The MS. was found there.

In July and August 1812, experiments at Sutton were made to ascertain the greatest range at which the spherical case shot could be fired with effect. It was then proved that at 2300 yards the effect from field howitzers "would be very destructive, and such as no body of troops *en masse* could bear."

Defence of *Tarifa*, December 24, 1812, by Colonel Skerritt. "On the investment the French light troops suffered considerably from our shells" (two light 6-prs.), Colonel Skerritt's dispatch; Colonel Jones, R.E., in his "Journal of Sieges," has "a great deal of effect was evidently produced on the besiegers by spherical case burst amongst them from the 6-prs. on the north-east tower (*a*), and also from the 24-prs. in the island, which fired over the town without molestation to the inhabitants, or defenders."

Salamanca, July 22, 1812. The Duke knowing that Marmont was about to be joined by the cavalry and artillery of the army of the north was anxious to fight without delay. Marmont, extending his left, gave the Duke a

chance. "There never was an army so beaten in so short a time." A Frenchman said, "40,000 men in 40 minutes;" 11 guns, 2 eagles, between 6000 and 7000 prisoners, and the number of dead on the field very large. Our losses were,—

	Killed.	Wounded.	Missing.
British	388	2117	74
Portuguese	304	1552	182
	692	3669	256

Major R. Macdonald, R.H.A., writes, Woolwich, May, 1813, " * * * But the most destructive fire on that day (July 22, Salamanca), was with your shells from the five and a half inch brass howitzer, against four of the enemy's guns, and three 12-prs. and one howitzer, at a distance of about 1600 yards, which within the hour was driven from its position, and that principally by the fire of the howitzer alone, as the light 6-prs. were not much used on account of the distance, and then only round shot. The fire of the howitzer was noticed particularly by Lieut.-Colonel Dowaman, commanding the horse artillery, who was on the hill at the time, and by several general officers.

"I likewise used it against columns of the enemy's infantry, when moving to support an attack of their light troop on the village of Arapellas, at 1600 and 1800 yards with great effect," &c.

Here is Marshal Marmont's account of his wound, "Il était environ trois heures du soir * * * Quand un seul coup de cannon tiré de l'armée Anglaise, de la batterie de deux pièces que l'ennemi avait placée sur l'autre Arapilès, me fracassa le bras et me mit ainsi hors de combat. Je prêtais le flanc gauche à l'ennemi, et le boulet creux dont la pièce avait été chargée ayant éclaté après m'avoir depassè, le bras droit et le côté droit furent blessés."

It was then a "boulet creux," and not an "obus."

It is remarkable that some years afterwards Marmont being anxious to inspect a troop of our horse artillery, had presented to him, the very man who had laid the gun on the occasion referred to above.

Lieut. John Sinclair, writes again, "Fifth Division, Camp before Andai, October 28, 1814. I commanded three guns of Major Lawson's brigade, during a great portion of the attack (Salamanca), and can testify to the effect of shrapnel, both on the enemy's line, and on the French cavalry that advanced after the check sustained by the fourth division," &c.

In pursuit after Vittoria, June 23, 1813, "We overtook their rear guard near a village about two leagues from Salvatiera. They attempted to make a stand while the village was in flames, but a shrapnel shell from our horse artillery set them instantly in motion," &c.—*Surtees.*

The Duke says in a dispatch, June 22, 1813, "The artillery was most judiciously placed by Lieut.-Colonel Dickson, and was well served, and the army is particularly indebted to that corps," &c.

The practice tables are approaching perfection, and at the recommendation of Colonel Robe, Lieut.-Colonel Dickson, and Lord Wellington, musket are substituted for carbine balls, in the spherical case.

PENZANCE,
Dear Sir, August 21, 1813.

Be so good as to acquaint General Farrington and the Committee that the tables now forwarded are extremely correct, and may always be relied on, &c.

Major Gold, H. SHRAPNEL.
&c., &c., &c.

WOOLWICH,
Sir, September 14, 1813.

I herewith send you a copy of Colonel Shrapnel's letter and experiments lately carried on with spherical case shot in Mounts Bay from a medium 12-pr. and a 9-pr. with the charges for round shot, which may be useful to you in using that description of ammunition. As soon as the Colonel has formed tables for the other natures of ordnance they shall be sent to you; I beg to inform you that in the mean time Lt.-Col. Shrapnel has proved by experiments, that spherical case shot for all natures of field ordnance may be fired with effect with the service charge for round shot.

I have the honor to be, &c.,
Major Williamson, A. FARRINGTON,
&c., &c., &c. General.

The old story, "changes in ordnance." Major May writes:—Mealhadu, Sardu, March 24, 1813, "We are now about changing my fuze for your catgut ones, of which we shall have about 20,000 in the country. Pray what said Mr Wellesley Pole to you about the success of the shell at Badajos?"

Mr Wellesley Pole was probably too much taken up with Irish affairs to say much.

Vittoria. June 22, 1813. Penzance experiments still going on, but the "general rules" were made known and "catgut" fuzes served out. "We took, in this battle 151 pieces of cannon, 415 ammunition wagons, 14,249 rounds of gun ammunition, 56 forage, and 44 forge wagons, 1,973,400 musket ball cartridges."

"The army indebted to the artillery."—*Duke's Dispatch.*

"Their artillery* was more than usually well served."—*Fraser.*

Our losses were,—

	Officers.	Serjts.	Rank and file.	Horses.
Killed	33	24	683	93
Wounded...	230	172	3768	68
Total	263	196	4451	161

Sir John May writes:—Head Quarters, Le Gear, September 17, 1813, "As soon as the practice and general rules reached me, I had them copied and sent round to each troop and brigade. That the shells might, as to the fuzes, have the fairest play, I brought from Portugal 6000 *catgut* fuzes, and gave them out to every troop and brigade, a week before the battle of Vittoria. In the battle it was not possible exactly to observe the effect of your shell, as the enemy's artillery and troops were greatly obscured by the smoke from their own guns."

* The French.

The Brigade-Major takes care, this time, that the captains shall have copies of the rules, as well as "catgut fuzes."

Badajos. Sir John May says:—"I understand (at this siege) from the Spaniards that the French complained much of the effect of the shrapnel case shot, which they said was new to them, and that the English must have poisoned the balls, as the men hit by them never recovered from the effects of their wounds," &c.

Evidence goes to shew how the French musketry fire was kept down, and guns were prevented from being remounted by the fire of shrapnel at this siege; but the paper is limited, and room must be kept for other extracts.

The late Sir Robert Gardiner, although not approving of shrapnel under all circumstances, gives a remarkable instance of its efficacy at Badajos:—"At the last siege of Badajos, our batteries were excessively galled by the fire from the south flank and face of the St Pedro bastion. It soon became our object of course to enfilade and silence this annoyance; but neither round shot or common shell, though plunging in ricochet and exploding over the bastion could do it. At last we resorted to shrapnel, and that silenced our friends very soon."

"On the fall of the place I went to the spot, to examine and ascertain if any traces of the effect of our fire remained.

"I found the left cheek of every gun carriage in the enfiladed flank of the bastion perfectly riddled with balls from our shrapnel. In fact, I don't think they fired half a dozen rounds from this point, from the time our enfilade began. No man indeed could stand to the guns under such a shower of balls."

St Sebastian. The effects produced by shrapnel at the siege of St Sebastian were very remarkable. Major-General Sir John T. Jones, K.C.B., Royal Engineers, in the "Journal of Sieges," states:—"The spherical case shot from the 68-pr. carronades appeared to have very great effect; and it was afterwards ascertained that the garrison suffered much from this species of ammunition. They endeavoured to retaliate the annoyance on the besiegers, and with that view fired shells filled with small balls, to burst over the heads of the troops, but which produced no effect."

General Rey, the commandant, wrote to Soult as follows:—Août 29, 1813, "Vous ne pouvez, Monseigneur vous faire une idée de la quantité de bombes et d'obus que l'ennemi y lance. Dans la ville c'est une grêle continuelle d'eclats d'obus, de boulets creux et de balles."

Pleasant.

The attempt to retaliate must have been amusing to scientific observers. A tremendous burst, but "no effect." A hint for the French arsenals.

Belmas, "Défence de Saint Sébastien, 13 Nuit, du 23 au 24 Juillet,—Au jour les Anglaise firent de toutes leur batteries un feu terrible, tant sur les brèches que sur la ville. Ills lancerent une immense quantité de boulets creux, renfermant jusquà quatre cents balles."

L'Adjutant commandant de Songeon chef de la place pendant le siege, fait dans ses rapports les remarques suivants:—

"Ces projectiles nous causerent beaucoup de mal. Il serait à désirer qu'on s'occupât dans nos arsenaux d'en confectioner de semblables. Quand vos obus ou boulets creux ne peuvent contenir que soixante ou soixante dix balles, il paraitrait ridicule que ceux de l'enemi en contenaient, jusqúà

quatre cent onze, si la verification n'avait été faite sur un obus de sept pouces quatre lignes," &c.

General Rey, the commandant, gives some excellent advice to Marshal Soult:—"Saint Sébastien, le 7 Août 1813, à quatre heures du soir." After detailing the state of the garrison and defences, which have no immediate reference to this question, he says, "Il serait bien à désirer, Monseigneur, que le gouvernement adoptât comme moyen de défense les boulets creux; ce projectile que l'ennemi a trouvé le moyen de faire éclater à volonté, nous fait beaucoup de mal: n'en ayant pas, nous mettons dans nos obus une soixantaine de balles, ce qui nous reussit assez bien," &c.

Appearances are deceitful. The art of the artilleryman is not learnt in a day, and the French practice was not even, "assez bien."

Sir Augustus Frazer, writes of this siege in one of his letters, as follows: "I have just had a hasty note from Sir Richard Fletcher, brought by a fine fellow who has swum over from the other side. The object is to direct seven guns with spherical case against a working party now toiling in the ruins of the right round tower, and not visible from hence. We are firing delicately, since we are directing our fire over points which our troops are now passing."

"Firing delicately."—at a party "not visible from hence." This implies curved fire, and no little skill on the part of the gunners. Do we ever try this kind of thing?

"Ah! ces sacrès boulets creux." Let the following narrative by a captive be well digested.

An English officer, the late General Sir Harry Jones, Royal Engineers, was wounded and taken prisoner whilst leading the assault, during the first attack of St Sebastian. An unwilling spectator of our artillery practice upon the castle, he says, "During this period every one sought shelter where best he could among the rocks, still no nook or corner appeared to be a protection from the shrapnel shells. The shriek of the bullet from a shrapnel shell is very different from the whistle of a musket ball; and oft repeated were the exclamations, *Ah! ces Sacres boulets creux.*"

"None but those who have been exposed to the effects of shrapnel shells can fully appreciate the advantages of possessing such a terrific and destructive missile. It appeared to be of little avail where a man placed himself for protection. No place was secure from them; and many a soldier was wounded without having been aware that any shell had exploded in his neighbourhood."

An extract or two from Belmas are added.

"July 20, 21, At break of day the enemy recommenced his fire, which he suspended at eleven o'clock a.m. to summon the governor to surrender; but ten minutes after the return of the messenger, the fire recommenced and lasted all the day. A great number of our guns were dismounted, and many of our carriages broken. All the embrasures constructed in masonry were destroyed, and their splinters placed *hors de combat* a pretty good number of gunners.

"July 21, 22, In fifteen hours and a half the breaching battery fired three thousand five hundred rounds from ten 24-prs., or at the rate of three hundred and fifty rounds per piece: few examples are to be found of so rapid a fire."

In connexion with this part of the subject, it may not be considered out of place to give a list of the battering train collected in the harbour of Passages for the siege of Bayonne, in 1814.

24-prs., iron	52	10-inch mortars	19	
8-inch howitzers	22	4⅖-inch coehorn do.	20	
68-pr. carronades	16	18-prs.	6	
13-inch mortars	4	Total	139	
24-pr. round shot		71,730	91,040, or 1750 rounds a gun.	
" grape		3,380		
" spherical		15,930		
18-pr. round shot		23,413	29,145.	
" grape		1,382		
" spherical		4,350		
For 68-pr. carronades and 8-inch howitzers.	round shot	700	19,994, or 500 rounds each.	
	case and grape	1,500		
	spherical case	10,266		
	common shells	7,328		
	carcasses	200		
13-in. common shells		1,694	1797, or 450 rounds each.	
" carcasses		103		
10-in. common shells		5,705	6990, or 368 rounds each.	
" carcasses		220		
Rounds of pound shot, 10-in.		1,065		
4⅖-in. shells		8,000	8400, or 420 rounds each.	
" carcasses		400		
Barrels of powder, 90 lbs.		10,160		

The following letter from an unknown (to me) correspondent of the "Times" is here inserted; just the kind of observer we want; creeping close up, and then going afterwards "to see what effect our shells had had." "Certainly they behaved well."

HEAD QUARTERS, LEYACA,
August, 1813.

* * * "I got down the hill as fast as I could, and crept close up to Captain Cairns' brigade of artillery, belonging to the 6th Division, who opened upon them a dreadful fire. Mind, when Capt. Cairns began, three French columns were not above 200 yards from our guns, engaged with our infantry. I was about 100 yards on one side of Cairns' guns, so that I could plainly see the effect of the fire; for one hour the French stood exposed to five pieces of artillery playing on them with spherical shells; I saw them fall by dozens, such gaps in their lines. * * * certainly they behaved well on this occasion. Their dead which I saw in the village, and on the hill were very numerous as I got up the hill to see what effect our shells had had," &c.

Here is another passage of a river,—the Bidassoa,—in face of the enemy. "Seven columns, attacking on a line of five miles. Tides rising sixteen feet," and two hours to do it in! Our guns at first protecting the passage, and then crossing.

Lieut. J. Sinclair, R.A., says,—"General Hay has taken me as aide-de-camp; the first duty I was on with him was in forcing the passage of the river Bidassoa, and entering France. The difficulty of the roads prevented the artillery coming up as soon as might be wished; however some shells were thrown at the close of the affair, which made them take to their heels," &c.

The brigade of General Hay in particular distinguished itself.—*Annals of Peninsula Campaign.*

The following extract from a paper in the U.S. Magazine for 1841, shews that shrapnel were used in America in 1814, with some effect:—"The ranges for cannon in Canada are short, from the frequent occurrences of patches of wood in the clearings, so that a long shot cannot be obtained; a range of 800 yards is as much as can be got in general; and as the roads are very bad, wheel carriages are of little service, from the difficulty of getting them across the country in the spring and fall. I am rather partial to light 6-prs., though they are a little out of fashion at Woolwich, but they are nice sharp little fellows, and can be got anywhere, and if a spherical bursts among a party of men they will never think of enquiring whether it contains twenty-seven or thirty-six balls inside. * * The Americans are pretty considerable bad artillerists, and used to complain sadly of our 'tarnation spiritual split shot,' as they called our spherical case, *Artillero Viego.*"

Waterloo. The allies numbered about 72,000, with 186 guns. The French 80,000, with 252 guns. Had Napoleon brought up his howitzers and burned Hougomont early in the day, or could he have held La Haye Sainte, the result of the battle might have been different indeed.

The loss of the French in the battle and pursuit was about 40,000. The British and Hanoverians about 10,686.

Few of us know how well the shrapnel was applied in this battle. Let the following letters instruct us, if not too proud to take a lesson from old fashioned things. "The Duke ordered your shells to be fired."

Perhaps the most interesting letter, to us, of the series, is this one from the late General Sir George Wood, who commanded the artillery at Waterloo, dated from the village, and written, immediately after the action, to Shrapnel. After describing the attack on Hougomont and repulse, and the subsequent attack by infantry and cavalry in the centre, and their holding La Haye Sainte, the *point d'appui* of the British centre, he says,—"Then the Duke ordered your (shrapnel) shells to be fired in and about the farm house, and thus succeeded in dislodging them from this formidable position, to which if Buonaparte had once been able to bring up his artillery, the Duke must have lost the battle; that had it not been for these shells, it is very doubtful whether any effort of the British could have recovered the farm house, and hence on this simple circumstance hinges entirely the turn of the battle," &c.

"L'artillerie Anglaise faisait dans nos rangs un ravage affreux, et nous y étions tellement exposés, que les projectiles traversaient facilement toutes nos lignes et tombaient fréquemment au milieu de nos équipages, arrêtés sur la route et les environs. * * Notre artillerie répondaient avec beaucoup d'energie et de vivacité; mais il est probable qu'elle avait beaucoup moins de prise sur l'ennemi, dont les masses ne pouvaient être ajustées que par approximation, parcequélles étaient presque entierement masquées par les dispositions du terrain." Then describing the final attack of the Guard, he says, "La garde charge à diverses reprises, mais ses efforts sont constamment repoussés; foudroyés par une artillerie epouvantable, et qui semble se multiplier, ces invincibles grenadiers voient leurs rangs s'éclaircir sous la mitraille, &c."—*Relation, par un témoin oculaire.—Troisiéme édition.*

Lieut. John Townsend, R.A. says, "They (shrapnel), were used with very considerable effect, both at the wood and orchard of Hougomont, as also upon masses of Jerome's attacking columns. I can bear in mind most fully how efficacious they were, both in clearing the wood at Hougomont, as also in the chasms made in the French attacking columns," &c.

Shrapnel continued his labours at Mounts Bay for two years after the termination of the great war. The Master-General then orders all experiments to cease, except such as can be carried on at Woolwich, and they were made in 1819. From motives of economy the subject was then allowed to drop.

It appears that the action of shrapnel was not understood in France, even as recently as 1834. The following extract from a French work on the application of iron will explain this: "Dans ce siége (St Sebastian) qui fut repris à deux fois, plusieurs cannons supportèrent au dela de trois mille coups à boulet roulant sans être endommagés dans l'ame. Leur tir était encore si juste à la derniere attaque, qu'on les employa à lancer par dessus les colonnes assaillantes des boulets creux dits shrapnells, pour ecarter les assiégés qui garnissaient le haut de la bréche."

Note.—Then after describing the effect produced on a field of battle by *projectiles creux*, the author goes on to state, "Ces boulets, connus sous le nom de *shrapnell*, sont coulés en font très-tenace, de manière à présenter, sous de parois minces, une résistance suffisante pour ne point rompre dans l'âme des bouches à feu qui les lancent. Le vide intérieur est rempli de poudre et de balles de plomb variant en force suivant le calibre.

"Les shrapnells sont munis de fusées dont la durée est calcalée suivant la distance où l'on veut obtenir l'explosion. Contrairement à ce qui se pratique dans le tir de nos obus, les Anglais font éclater leurs shrapnells, non *apres* leur chute, mais dans le cours de la trajectoire, lorsque ces projectiles sont encore animés d'assez de vitesse pour porter en avant leurs éclats et les balles qu'ils renferment, avec la force necessaire pour tuer ou blesser grièvement.

"Les détails de la construction des shrapnells sont peu connus en France, mais d'après l'esquisse qui nous venons d'en donner, on voit que ces projectiles ne sont autre chose que des boites-a-balles sphérique destinées à étendre les effets du tir à balles à des distances où l'on n'atteint qu'avec le boulet.

"Cette faculté de pouvoir porter dans les rangs ennemis les ravages du tir à balles jusqu' à la distance de 1200 mètres avec des canons de campagne, puit avoir d'incalculables conséquences sur un champ de bataille. Il nous paraît qu'une telle invention mérite d'exciter au plus haut degré la solicitude du gouvernement."—*Thiery, Applicatione du fer.* 1834.

Here is some Indian experience before the Crimea war began.

In the life of Sir William Nott we find this passage. "Our guns played at intervals with grape and spherical shot, admirably served, so as to burst and meet the ascending foe on the sides of the cliffs, and it was the only satisfaction left us to see them fall by dozens on the explosion of each shell, as they came driving furiously into the Bolan Pass," &c.

On the question being put to General Nott, he replied, Carmarthen, 6th Nov. 1841. "I have always had the highest opinion of the value of

shrapnel shells, and found them of the greatest service during my campaign in Affghanistan, more especially in the valley, and at the battle of Medanse, when they enabled me to keep the enemy at bay for three days.

Lieut. Greenwood, 31st Regiment, thus describes his sensations on being fired over, as our people had previously been at St Sebastian. "General Pollock forced the Kyber Pass. The Kybarees had fought well * * hundreds of Kybarees had been mowed down by the shrapnel shot from the artillery, and altogether they had sustained a serious defeat." Again, at the battle of Tezeen. "The height on which we were, was commanded by other hills which were from our position perfectly inaccessible, and from which the Affghans, in number about ten thousand, kept up a most incessant and galling cross fire. At a particular part of the pass where an opening occurred for the use of the artillery, we were ordered by signal from below to lie down, which being obeyed, the howitzers began to throw shrapnel shells over us among the Affghans who lined the heights which towered above those we occupied.

"The situation was to us about the most unpleasant in which we could be placed. The shells kept whistling past about three or four feet above us, and had one by accident burst before it was intended to do so, no small harm would have been played among us by our friends. The shells, however, were admirably directed, and they soon had the desired effect among the enemy. After the lapse of about a quarter of an hour he (the General) returned and the force was ordered to advance. The horse artillery guns were now opened on the hills to the left, whilst Major Apthorpe, with the light battalion, was instructed to storm the hills to the right. Leslie's battery played with good effect, throwing its shrapnel among the enemy; but the infantry column was disastrously beaten back," &c.

From Brigadier Monteith, C.B., to Captain Ponsonby, A.A.G.:—Camp Mayeena, July 27, 1842, "At this moment the guns having been brought into position by Captain Abbott, opened a fire of shrapnels upon them, which did considerable execution, and so disconcerted them, that parties left the field altogether, and never returned."

The advance into the Kyber Pass, and the evacuation of the fort of Ali Musjid,—

From Major-General Pollock to the Secretary to the Government of India:—Ali Musjid, 6th April, 1842, "While the flanking columns were in progress on the heights, I ordered Captain Alexander, in command of the artillery, to place the guns in position and to throw shrapnel among the enemy when opportunity offered, which assisted much in their discomfiture."

Goojerat, Feb. 21, 1849. An artillery battle.

"Feb. 25. The banks of the Jhelum. I must write you an account of this the second action I have been in, the battle of Goojerat. * * * The day was the clearest and brightest I ever remember to have seen, and we had a level plain of about twelve miles square with scarcely a mole hill to be seen. * * * Think what a splended sight it was to see a line of upwards of five miles long advancing across this plain. As soon as we got within half a mile of them they commenced throwing their round shot at us,

when the artillery went to the front and began to send in round shot and shrapnel with tremendous effect: they were supported by two regiments of cavalry and we brought up the rear. * * * The enemy could not stand our spherical cases, or, as our soldiers pronounced the word *spiritual* cases, and to see the panic they created, it was not a bad name for them. Our cavalry and artillery followed them up for twelve miles," &c.

Letter, "Morning Chronicle," April 26, 1849. "In this battle 25,000 British defeated 60,000 Sikhs. Our loss was only 5 officers, 52 rank and file killed, and 23 officers, and 682 rank and file wounded.

Shrapnel at the Cape again.

The Kaffir war. Colonel Mackinnon, C.B. in reporting the relief of Forts Cox and White, states, "King William's Tower, Feb. 1, 1851. * * * Shortly afterwards large bodies of the enemy appeared on our left, evidently bent on contesting our march across the Debe Neck. Two shells directed with great precision by Major Wilmot of the Royal Artillery,* (from *one* 6-pr. gun) were thrown into the midst of a large group and did great execution. * * * Whilst the troops were at the post (Fort Cox) a large body of Kaffirs appeared upon the brow of the hill which overlooked Keiskamma, apparently in the expectation that we intended proceeding to that post. Two shells were again accurately directed by Major Wilmot, and caused them considerable loss," &c.

Major Rowley, R.A. writes, "On the day on which Macomas Den was captured I kept up a sharp fire of shrapnels into the Den under cover of which the infantry advanced, and stormed the position, which was very strong, with little loss. The late Sir William Eyre who commanded attributed this to the fire of the guns, which had proved very effective as numbers were found killed."

Again, "On one occasion, towards the close of a skirmish in which the Rifle Brigade were engaged, and in which Sir George Buller commanded, I remember, the Caffres (thinking that they were out of range) getting into clumps, I laid a gun (6-pr.) myself, at about 1900 yards with a shrapnel shell, it burst close to the group, and we saw that some of them were down; they immediately fled, &c. The shrapnel shells were common old pattern ones, into which the bursting charge had to be shaken amongst the bullets."

On the 2nd June, 1852. The Select Committee report that they see no objection to the *spherical case shot* being named *Shrapnel.*

Some notices of the application of shrapnel at the siege of Sebastopol,—

"4th November, 1854. A large working party of the enemy shewed themselves at a new work in front of the Tower. They were driven away by 24-pr shrapnel shells fired from the right attack.

"12th February. Captain Campbell, R.A., this day on duty in the right attack, seeing a large working party of the Russians under the Malakoff, dispersed them with two 24-pr. shrapnel shells; the enemy replied with 53 rounds.

"21st March. The 9-prs. opened on the rifle pits, at about 900 yards range, making very excellent practice with round shot and spherical case.

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* Brother of Colonel F. Eardley-Wilmot, R.A., Commandant, Shoeburyness.

"22nd March. Five shrapnel shells were also fired, and burst most accurately, but caused little disturbance to the riflemen.

"7th June. * * * the three guns from No. 9 doing execution with shrapnel against the retreating Russians.

"At 6·30 the French advanced and took possession of the Mamelon. Our mortars and guns were at once turned on the Malakoff, the three guns from No. 9 doing execution with shrapnel against the retreating Russians."

Lieut.-Colonel Hamley, R.A., states, "by widening an embrasure a second gun was brought to bear on them with spherical case and proved very destructive; prostrate men, broken carts, and run-away horses marking its effects."

As regards operations during the mutiny in India, we have some brief record in the Reports of the Officers, as published in R.A. Institution papers,—

Major Singleton, R.A., says, Mooltan, Sept. 2, 1858, on the repulse of the mutinous Sepoys of the 62nd and 69th Native Regiments at Mooltan, "I observed another party of the mutineers advancing in a body along their parade ground to my left, so I ordered shrapnel to be fired, which did great execution, and the enemy went flying in every direction," &c.

Lieut. Strange, R.A., at Sultanpore, August 30, 1858. "28th instant, about 11 a.m. a body of cavalry on the left rear of our skirmishers, dispersed by a shrapnel shell," &c.

Battle of Pandoo, Nuddee. Colonel Maude says, "I made up my mind to advance and try conclusions with their heavy guns; accordingly we moved smartly along the road, under a very heavy fire, which directed at us did much damage just to our immediate right and left, till within 600 yards of their position, and by a most wonderful providence, in three rounds, we* broke both the sponge staves of their heavy guns!! upon which after an ineffectual attempt," &c.

The landing at Simonasaki, September 6, 1864. Shrapnel was largely and effectually used from the 32-prs. of the *Argus*, to drive the Japanese out of the woods, and cover the boats.

We have seen that against some of the best troops; in all climates and operations, whether applied in direct, enfilade or curved fire; whether over our friends heads or otherwise; against columns, line or skirmishers; in attack and defence; hurried and deliberately; there is abundant evidence of its value when rightly used. More than this, our enemies marked and dreaded its effects, and in one instance at least endeavoured to copy it.

If I shall have been the means of stirring up the minds of my brother officers to consider this vital question,—or take an interest in the history of the Regiment, and claim the credit which is justly due for our share in the great events which have been merely named in the foregoing pages, I shall be satisfied.

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* "Our shrapnel bullets."—Memoirs of Havelock, Marshman.

BOXER'S WOOD TIME FUZE FOR M.L. ORDNANCE (RIFLE AND SMOOTH-BORED).

BY CAPTAIN VIVIAN DERING MAJENDIE, R.A.

ASSISTANT SUPERINTENDENT, ROYAL LABORATORY.

In a recent number of these "Proceedings"* was published an account of the Pettman General Service fuze which has been adopted for the majority of rifle and spherical shell, and may practically be regarded as the percussion fuze of the service.

The time fuzes for the shells which take the general service fuze are two wooden fuzes designed by Colonel Boxer, on the principle of his well-known "Common Fuze."

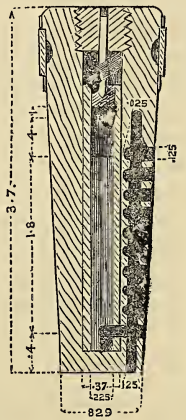
The general adoption of these fuzes marks the abolition of naval *metal* time fuzes, after a continuous service of about 35 years.

The two fuzes are respectively :—

1. The 9-seconds fuze for M.L. ordnance.
2. " 20 " " "

1. *The 9-seconds fuze for M.L. ordnance*† resembles the common fuze in its main features of construction, but differs from it in several points of detail.

Fig. 1.



* Vide p. 292.

† Approved 26th June, 1866, W.O.C. 10 (New Series), § 1236.

The points of difference may be most conveniently explained by arranging them under the following heads :—

(1) Points of difference in the head of the fuze;

(2) Points of difference in the body of the fuze;

(3) General dimensions.

As regards (1) *The head of the fuze:* The principal difference here consists in the introduction of a gun-metal plug, which is screwed permanently into the upper part of the composition bore, flush with the top of the fuze. The object of this plug is to close the top of the fuze completely, and so to prevent (*a*) the extinction of the fuze when striking end on, and (*b*) the great acceleration of the rate of burning of the composition which is induced by the pressure of the air on an unprotected fuze fixed in the apex of a rifled shell.*

The presence of the plug necessitates a different method of priming. From the centre of the plug projects downwards a copper pin, round which is looped a piece of quickmatch, the ends of this match being passed through two escape holes which are provided in the side of the head for the escape of the flame from the burning composition.

The quickmatch is laid in a groove round the head of the fuze, and is covered by a strip of thin sheet copper,† the copper being covered by a tape band,‡ and one end of the copper band being exposed.

The band and upper part of the fuze are painted black, the top of the fuze is varnished with shellac varnish.

(2) *The body of the fuze* differs from that of the common fuze principally in being lined with a paper§ cylinder. This lining serves two purposes, 1st, In the event of the wood shrinking as it will sometimes do in dry, hot

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* The extent to which this acceleration takes place is indicated by the fact that the total acceleration of the time of burning of a 20-seconds metal time fuze which has no such plug, fired in a 64-pr. M.L. shell, is 3 seconds; i.e. a 20-seconds fuze burns only 17 seconds.—*Minute by General Lefroy*, 18/7/65 on 75/7/1329. The difference would of course be greater in shells having a higher velocity.

† The copper band is 5·1″ long, ·3″ wide, and ·002″ thick, the end is tapered slightly.

‡ The object of covering the quick-match thus carefully, is not merely to protect the priming from moisture, but to secure the fuze against accidental ignition. An experiment was made in the Royal Laboratory at Woolwich, in March, 1865, to determine how far the fuzes were secure in this respect. The result was satisfactory. The following are the details of the experiment:—

Four 7″ B.L. common shells placed upright, and a 10 lbs. cartridge exploded in centre, and this repeated a second and third time with same fuzes; none of the fuzes ignited.

Four 7″ B.L. common shell placed round a 10 lbs. cartridge, with the fuzes resting on the cartridge, a cartridge exploded, this repeated a second and third time. One fuze out of twelve may be expected to light.

§ "White wrapping" paper. The outside of the cylinder is varnished with shellac before being placed in the fuze.

climates, it prevents the formation of a space or groove between the wood and composition which would cause the fuze to explode* instead of burning regularly; and, 2nd, it enables the side holes to be made deeper, thus diminishing the thickness of wood to be bored through in preparing the fuze.

In addition to being deeper, the side holes differ from those of a common fuze in being plugged with rifle powder only, the ground clay being dispensed with. The bottoms of the powder channels are not, as in the common fuze, closed with shellac putty, but like those of the diaphragm fuze, are connected at the bottom with a piece of quickmatch.

Above the level of the top side hole the composition bore is driven with mealed (pit) powder instead of fuze composition, to ensure greater accuracy when the fuze is prepared for short ranges.†

(3) *In dimensions* this fuze differs from the common in being altogether about one inch longer to give room for the plug, and in being cut from a somewhat thicker part of the same cone.

In other respects the construction is identical with that of the common fuze.

Preparation. The preparation of the 9-seconds and common fuzes is the same, with the exception that the 9-seconds fuze is uncapped by stripping the tape and copper band from the priming, by means of the exposed end of copper which is left to lay hold of.

This should not be done until the shell is in the bore of the gun.

With reduced charges, to ensure the ignition of the fuze, it may sometimes be necessary to further expose the quickmatch priming—a slight touch with the fingers will easily make the ends of the quickmatch project from the groove,—and when very reduced charges are used, two or three strands of quickmatch should be tied in addition round the projecting part of the fuze.

Action. When the fuze composition becomes ignited, it burns out of the two escape holes provided for the purpose, the action in other respects being the same as that of the common fuze.

The 9-seconds fuze can be used with all muzzle-loading shells having the "General Service" fuze hole or adapter, and in addition to being used with all M.L. rifled shells so fitted, it has been adopted for use with naval spherical shell‡ having a suitable bush or adapter. It will gradually

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* On the principle of a tube.

† Pressed mealed powder burns twice the rate of fuze composition, and thus by substituting mealed powder for fuze composition twice the length is obtained, the chance of the boring tool cracking the composition as it would be liable to do if it entered near the top, being thus diminished, and the accuracy of the fuze at short ranges increased.

‡ For reasons which induced the Ordnance Select Committee when engaged on the assimilation of fuze holes not to attempt to extend the assimilation as far as spherical shell were concerned to any but "naval shell," see *Extracts O.S.C.*, Vol. IV. p. 143, *et seq.*

supersede the $7\frac{1}{2}$-seconds fuze for these latter shell.* It is available for times of flight from 1 to 10 seconds.†

2. *The 20-seconds fuze for M.L. Ordnance*‡ resembles in part the 9-seconds fuze for M.L. ordnance, and in part a mortar fuze.

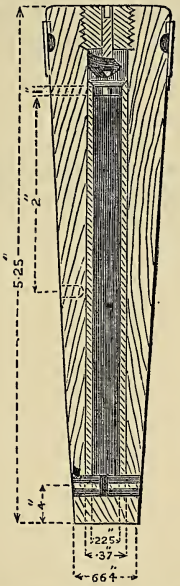

Fig. 2.

It has, that is to say, the metal plug in the head, the escape holes, the priming, and copper and tape bands round the head, and the paper lining, which are characteristic of the 9-seconds fuze, while in respect of having only one row of side holes disposed spirally, and of having no powder channels, its construction is that of a mortar fuze.

In two respects the fuze differs from both those which it generally resembles. It contains four inches of fuze composition,§ and a hole is bored transversely through the fuze immediately below the composition for the reception of a pellet of mealed powder pierced like a tube. The ends of the hole are protected by discs of thin paper secured with shellac varnish. Notation of the side holes is as in the large mortar fuze from two inches downwards; but each hole is marked, in lengths of inches.

Preparation and action. The preparation of this fuze is the same as that of the mortar fuze|| in so far as the boring is concerned; it is uncapped in the same way as the 9-seconds fuze.

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* W.O. Letter, 5th July, 1866, 75/12/2852, and W.O.C. 10 (new series), § 1236.

† The fuze is called a 9-seconds fuze because this is its mean time of burning *in rifled shell*, in which notwithstanding the plug a certain acceleration of burning does take place. In a spherical shell, however, the fuze will burn the full time due to 2 inches of composition, i.e. 10 seconds.

‡ Approved, 7/6/'67. W.O. Letter 3/7/'67 $\frac{75}{17\frac{1}{2}}$

§ There is ·1″ of mealed powder on the top of the composition bored into to facilitate ignition. But as the hole all but extends through the mealed powder, this pellet does not appreciably increase the time of burning of the fuze.

|| But owing to the side holes being bored deeper is not nearly so slow or laborious.

Action. Its action is that of a mortar fuze, with the addition of a certain increased violence or intensity of action due to the powder pellet in the bottom, when the fuze is left to burn full length.

The 20-seconds M.L. fuze can be used with the same shells as the 9-seconds M.L. fuze, i.e. all M.L. shells, rifled or smooth-bore, having the general service bush or adapter. It is available for all times of flight from 10 to 20 seconds.* and will ultimately supersede the metal 20-seconds fuze for naval shell.

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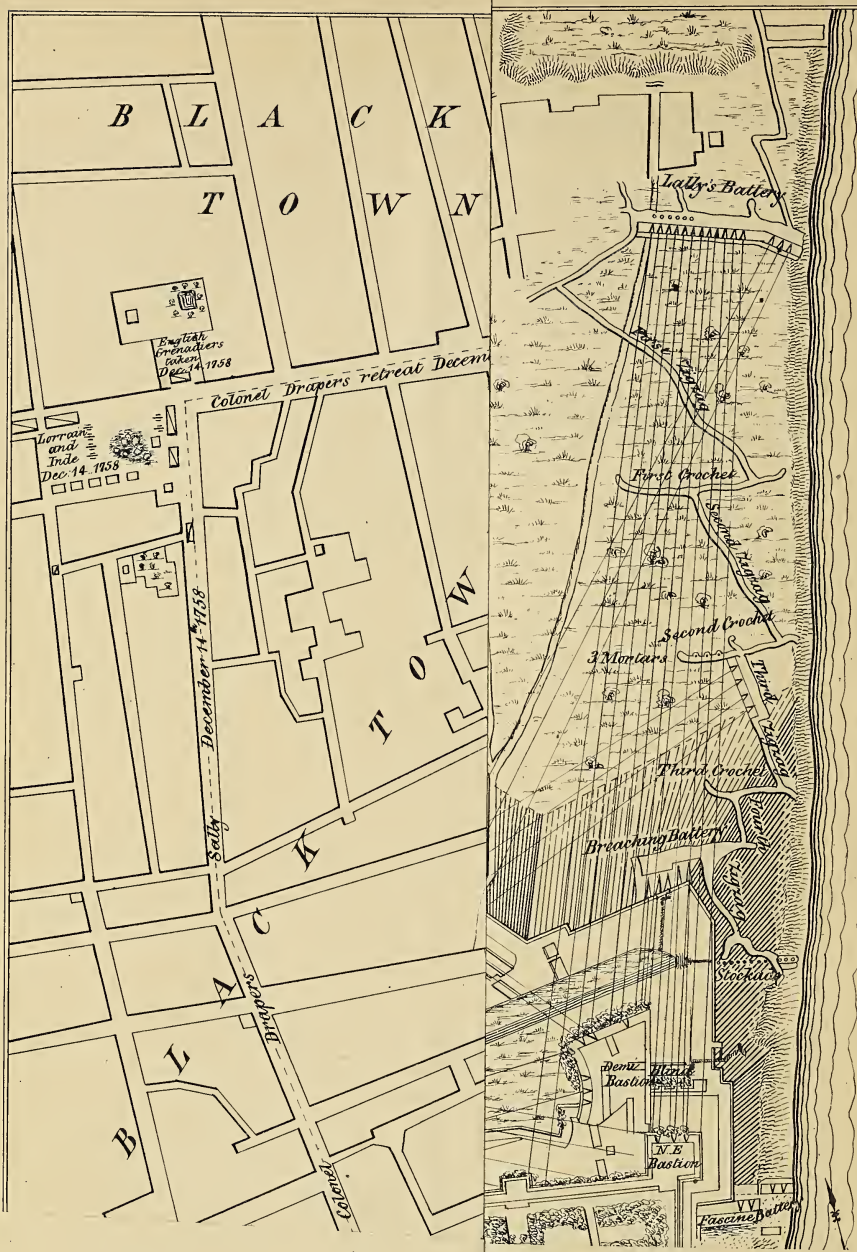
* In spite of the plug a certain acceleration of the rate of burning takes place in rifled shells and the mean time of burning of the fuze in rifled shell would probably be about 18 seconds. But the fuze would burn its full time in spherical shell.

B L A C K T O W N
B L A C K T O W N
Regiment December 14. 1758
Lally's
four Mortars
Lally's Battery
Burying Ground Battery
Burying Ground
Colonel Draper's retreat December 14th 1758
Colonel Draper's retreat
Colonel Draper's retreat December 14th 1758
Sally December 14th 1758
Lorrain and Inde Dec. 14 1758
English Grenadiers taken Dec. 14 1758
Corsan Battery
Breaching Battery
North Bastion
Ravelin
Demi Bastion
Old N.W. Bastion
N.E. Bastion
Facame Battery
Wall of the old Town
Pigole Bastion
Barricade January 1759
French Attack
Hospital bat. Ricochet
Ricochet
First Crochet
Second Crochet
Third Crochet
3 Mortars
A Scale of Yards
10 20 30 40 50 100 150 200 250 300
PLAN
of the FRONTS of FORT St GEORGE
attacked by Mr LALLY
from the 14th of December 1758 to the 16th of February 1759
with part of the BLACK TOWN.
Lithographed at the Royal Artillery Institution


B L A C K
T O W N
English grenadiers taken Dec. 14. 1758
Colonel Drapers retreat Decem
Lorrain and Inde Dec. 14. 1758
Sally
December 14. 1758
Draper's
Colonel
B L A C K T O W
Lally's Battery
First Trench
First Crochet
Second Ragway
Second Crochet
3 Mortars
Third Ragway
Third Crochet
Breaching Battery
Stockade
Bomb Battery
N.E Bastion
Fascine Battery

THE SIEGE OF MADRAS.

BY SIDNEY OWEN, M.A.

LEE'S READER IN LAW AND HISTORY AT CHRIST CHURCH; AND READER IN INDIAN LAW IN THE UNIVERSITY OF OXFORD.

THE following paragraphs formed part of a Lecture which I had the honor of delivering, last spring, at the Royal Artillery Institution. The general subject was "The British Conquest of the Carnatic;" and the lecture included a concise survey of the principal operations of the war in which Count Lally, undertaking to exterminate the English, after capturing and destroying Fort St David, and unsuccessfully besieging Tanjore and Madras, was defeated at Wandiwash by Colonel Coote, and blockaded and compelled to surrender at Pondicherry. Several circumstances seemed to make it worth while to reproduce this very summary account of a siege which, in Orme's narrative, occupies some eighty 4to pages. An idea has prevailed extensively, that the Royal Artillery were not employed in India until recent times. This idea, incidentally refuted by a series of drawings executed by Lieut. J. Hunter of that Corps, about the year 1790, and lately presented to the R.A. Institution by Gen. Lefroy, here gives place to the fact, that Madras was defended by a body of Royal Artillerymen, under the active and able command of an experienced officer of that branch of the King's service. Again, though the sieges of Seringapatam were not less eventful either in themselves, or in their bearing on the growth of our power in India; they cannot vie with that of Madras either as an exhibition of our perilous situation in the East, or as integral and characteristic parts, on a new scene, of the long, obstinate, and world-wide struggle between ourselves, and those whom, until very lately, it was the fashion to consider our natural enemies. Thirdly, as has been pointed out below, the siege of Madras was, under the circumstances, the *experimentum crucis* of the whole war. Had Madras fallen, as it so very nearly did fall, Lally's history and our own would alike probably have been much modified. Lastly, it is hoped that this short but (I trust), as far as it goes, faithful account of an achievement in which their predecessors took so prominent a part may serve to attract the attention of Officers of the Corps, who may not be familiar with the pages of Orme, to a work that possesses, in so high a degree, the indispensable qualities and exemplary merits of a Military History. Lally's own explanation, full of interest and now very scarce, is too long to quote.*

* Cambridge's *War in India* contains a useful working Journal of the operations, by Mr Call, the Chief Engineer.

And now, at length, the main action of the great war drama was to begin in earnest. The traditional foes were to be pitted, in their full might, and with the mutual display of their highest energies and subtlest skill, against each other. The Exterminator was to meet, face to face, men thoroughly determined *not* to be exterminated; but, under the experienced command of the veteran Lawrence, to retrieve the disgrace of Fort St David, and to hold Madras against the French, as they had, again and again, against heavy odds, held Trichinopoly in former times.

On the 29th of Nov. 1758, the besieging army marched from Conjeveram. On the 4th of December Lally reconnoitred Chingleput, and, (adds Orme), "contrary to the sound rules of war, and perhaps his own conviction, determined to leave it in his rear."

It was, in fact, invaluable to the besieged as a *place d'armes* and rallying point for their outlying forces. As usual, the French commander was in a hurry to push on, when he could move at all. But Lawrence, though resolved not to engage in a general action, felt the importance both of giving confidence to his men, by not sheltering them too abruptly behind stone walls, and of gaining time, to facilitate the seasonable arrival of the fleet. He therefore made a stand first in the Choultry Plain, to the south-west of the city; then at the end of a sort of defile formed by enclosures on the south side of the main road towards Madras, and by the mound of a large tank, called the Meliapore, on the north of the road. Here he planted his field pieces; cut the mound, submerging the road; and skirmished with good effect for a time; whilst other approaches witnessed similar skirmishes. Gradually and coolly, and with little loss, he retired, withdrawing his various outposts as he went; and the English, fully mustered in the fort, looked out on the French army finally taking up its station in the Black Town. This the native quarter lay to the north and north-west of the fort, an open esplanade intervening; while of two rivers which met at the sea to the south of the fort, the more northerly one swept round the Black Town on its west and south sides, and forming a morass there, sufficiently protected it from the probability of the enemy's directing their serious efforts in that quarter. Lally's own regiment was stationed near the sea, on the north of the Black Town; Lorrain, and the battalion of India, more to the west, in the centre of the city.

The flying natives sought shelter in the fort, but were refused admittance, and escaped into the country. Spies and some deserters apprised the English that the enemy had taken to plundering the town, and were already in a state of drunkenness and disorder. This seemed confirmed by what could be seen from the walls. Draper accordingly urged, and led forth the same night, a strong sally to beat up the quarters of the French, before they should have time to recover their discipline. Emerging from the fort on the west, followed later by a covering party under Brereton, which was to halt on the esplanade, the sallying force crossed the river, ascended a rising ground, penetrated up a long street into the heart of the Black Town, before the enemy were in any condition to oppose them. Lally's men were far away, most of them "reeling drunk." Lorrain drew up in a street parallel to that in which Draper was approaching, facing down the street, and with two or three platoons advanced to the opening of a cross street. The Indian battalion of Europeans seems to have been further off, or in

worse plight than Lorrain; for they mustered slowly, in the rear of the other regiment. Lorrain had also four field pieces. Draper and his advanced grenadier corps received and returned the fire of the platoons in the cross street, but pushed on at once, leaving a party to seal this passage; and, on gaining the main transverse thoroughfare of the Black Town, discerned Lorrain on their left, presenting its naked flank. Instantly they faced and fired, aided by others as they came up; and the French suffered much from this, and more from the well served English field pieces, which drove them to cover in the houses; and though they turned their own guns and fired once, the gunners then abandoned their pieces; and Draper, stopping his own fire, ordered the grenadiers to follow him, and seize the French artillery. But they had pushed on into an enclosure opposite; how far to escape the French fire must be left to conjecture. Four men only followed Draper; and though he received from an officer who had stayed by the guns an offer to surrender himself and them, two of his four attendants being killed, and the others wounded, he was fain to return to his former station. Then the French emerged from their shelter, reinforced each moment by the gathering mass of the Indian battalion; the firing of guns and musketry raged hotly for twenty minutes; when Draper, afraid of being cut off by Lally's regiment from behind, notified a retreat; and the bulk of his party, abandoning their guns, pushed on for the esplanade. Here Brereton's covering force met them in good order; and thence they regained the fort; but in such a state of panic were many of the common men, that they scrambled over the glacis into the works. Lally's regiment, with Bussy at their head, gained the east entrance to the esplanade in time, but not in condition, to attack the retreating party; nor were they the more inclined to do so from the fact, that the fort guns commanded that open space. I said, Draper notified a retreat. No drummer appeared to sound one. Hence the grenadiers, sequestered in their enclosure, were unaware of it in time; and were compelled to surrender, as ignominiously as by the same number of men, (eighty) 6000 Beloochees were "cribbed, cabined, and confined," and parallyzed by Napier in the battle of Meeanee.

Many more English were killed in the houses, where their antagonists lay, killed also, beside them. Some 200 Europeans were slain or taken on each side. The loss of the grenadiers, "the prime men of the garrison," was poorly compensated by the death of Saubinet, and the capture of D'Estaign, the only officer whom Lally seems to have cordially liked and trusted.

The area comprised within the original fortifications of St George had been only fifteen acres. But latterly, and in anticipation of the present crisis, this space had been doubled, by an outer and more elaborate circuit of ramparts and bastions, on all sides except towards the sea; where a brick wall, four feet thick, with a battery of thirteen guns before the sea-gate in the middle of this wall, and a trench all along it, were the sole defences. From the proximity of the fort to the sea, no guns could reach the east side from the land; while the surf formed generally a tolerable security against a landing from the sea. The great danger, it will be seen as we proceed, was lest a force should come along shore, and attack the sea-gate. To guard against this, a fascine battery was erected close to the north-east angle of the old fort; and at each end of the new one a strong stockade, with a

trench, ran out into the surf. Between the new and the old walls (which were still retained), on the west and south sides, intervened a wet ditch, part of the channel of a choked up bed of the adjacent river, which had been diverted for the purpose. The morass also has been already mentioned. Our chief business now is with the north side, where the brunt of the attack and defence was to be waged. The great glory of the new works was the royal bastion. This, completely embracing the old north-west bastion, had three faces; each grinning formidable defiance from many embrasures; the eastern face curving inwards, and confronting a similar face of the demi-bastion, which partially covered the old north-east bastion, but left some of its guns free to range along the flank of the new work. A "blind" of earth had been raised to cover the exposed northern face of the old structure. A broad terrace (in non-military phrase) connected the royal with the demi-bastion. A trench, dry but deep and broad, and palisaded, ran in front of the whole line of defence on this side; which was completed by a strong north ravelin, opposite the curtain. I shrink from the perilous minutiæ of *cuvettes* and *caponières*, and other technicalities, the application of which I do not thoroughly understand; and need only indicate the position of Pigot's bastion and the north-west lunette, on the western side of the fort.

Though some time elapsed before the enemy were well supplied with ammunition, or even with guns (which they seem to have obtained mostly from their remaining men-of-war), they lost no time in constructing batteries, as follows. To the north, on the verge of the Black Town, and close to the sea, 500 yards from the fort, was raised what the English called Lally's battery, consisting of both cannon and mortars. While the latter threw shells into the town, and did much damage to the houses, the former bore chiefly on the demi and old north-east bastions; and, from an angle close to the sea, on the east face of the north ravelin. Four mortars were planted to the north of the burying ground. To the east of it, and named from it, another battery bore on the western face of the north ravelin, on the demi, and diagonally on the royal and old north-west bastions. The English styled the Lorrain a battery which enfiladed the royal, and sweeping the terrace on its eastern side commanded also the old north-east bastion; while a return, on the north of the Lorrain, bore on the north-west face of Pigot's bastion. Lastly, the hospital ricochet battery sent its terrible leaping missives over the north-west lunette, the old north-west bastion, and on to the demi-bastion. On the bar to the south the French also planted some guns, more to intercept communications between the garrison and their friends without the walls, than to bear directly upon the works.

They then actively pushed on trenches from Lally's battery towards the main object of their attack, the north-east angle of the fort; and ere long, at the second "crochet" (or demi-parallel) constructed another battery, also of both cannon and mortars; the guns bearing mainly on the east front of the north ravelin, preparatory to the erection of the breaching battery, close up to the glacis of the chief angle of assault.

On the other hand, every effort was made to retard and frustrate their exertions. So vigorous and well-directed was the fire of the fort that it again and again silenced for awhile the enemy's guns. Cannon were dismounted and ruined rapidly and constantly on both sides; embrasures had to be closed for repairs; and the sturdy and frequent sallies of the besieged, the

scantiness of artillery and ammunition on the part of the besiegers, and the too great elevation of their guns, rendered the progress of the attack for a time doubtful. But steadily and surely the French worked on at their trenches; and the second "crochet" was finished, and the advanced battery there erected, then damaged, and in a great measure disused.

The spirited sallies continued. Sometimes in small parties; sometimes in large bodies; now against a battery; then to interrupt the workmen at a trench; and again to fall upon a detachment, spike up or carry away a field-piece or two on the south of the town; or to communicate with and remit money to their out-skirmishers, who were operating on the rear of the French; the daring Englishmen, and Jemaul Saheb, the commander of the Sepoys, catching the hardy infection, distracted the attention, partially arrested the activity, disturbed perpetually the equanimity of their opponents; who yet, on the whole, with a determined spirit equal to their own, pressed slowly but surely onward to the foot of the walls.

The Nabob, meanwhile, and his numerous *suite* relished the confinement and discomforts of a besieged town less and less daily. Soon, with the full consent of the English, and indeed to their relief, he departed, to find refuge in Trichinopoly; and his followers were at once also got rid of. Pigot and his councillors were men wise in their generation. Yet it may be doubted whether they were clearly right in thus seeming to sanction the idea that Madras was not a secure place for their nominal sovereign. The king of Tanjore was certainly very unfavourably impressed by the departure of the Nabob; and hesitated, on that account, to comply with Calliaud's pressing instances for a reinforcement. The hostile fleets, meanwhile, were far away. But the French had two men-of-war, and some smaller vessels. And an English Indiaman arrived, and after safely landing a quantity of treasure and stores, especially shells of large size, very opportunely, Ingliss, her brave captain, animated by the same daring spirit that glowed in the breasts of the whole garrison, though offered the option of retiring from the scene, or running his ship ashore, determined to hold his station off the fort. And nobly he fulfilled that resolve. Though "stormed at with shot and shell" by both the men-of-war, the batteries from the north, and the guns on the spit to the south, his masts and rigging shattered; his hull pierced again and again, sometimes by red hot shot; he held on, till one of the men-of-war and a sloop actually fled out of the road, for fear of his executing a plan to cut them out; and the guns on the bar being wanted elsewhere were withdrawn; when he had some respite from the general assault on his stout craft. A field-piece placed, instead of the heavier metal, on the bar checked, without preventing, communications between the town and their outlying forces.

The French had, by this time, seriously damaged the works on the north; and having reached the foot of the glacis, commenced their breaching battery there. And now the contest became most obstinate, desperate, and deadly. The fire of the besieged silenced for awhile the breaching battery; but, as before, for awhile only; though that battery, at first, as Lally's before, fired too high. The demolition of the works, the destruction of guns, the casualties among the besieged, went on apace. The French seized, and turned against the English, the stockade on the sea-margin. Determined attempts were made to recover it, but in vain. It was abandoned. The French began to mine. The English countermined. On both sides it

happened that the mine, pushed on too rashly and too high, let in the daylight. But while the English took advantage of their opponents' mistake, and with musketry and grenades drove them back into their burrow; they succeeded in covering up their own opening, and taking a fresh start, without the false move being detected. And while the French exploded a mine, with little effect, on the verge of the salient north-east angle; the English finished leisurely their underground chambers, much to their own satisfaction; and lodged therein several hundred pounds of powder, for the warm and hospitable reception of the strangers, when they should make bold to cross the threshold of their honey-combed and tottering outworks. But an attack, along the shore, on the sea-gate, was now most immediately feared. They therefore, while repairing, as well as they could, but most inadequately, the injuries on the north-west face of the fort, reconstructed in haste the fascine battery, bricked up the sea-gate, opening a small wicket (as it were) on its side, threw out additional defences into the surf, and in more than one vigorous and obstinate sally overturned into the sea, or dragged into the covered way, the gabions which the French were accumulating at the stockade; repulsing, and firing smartly and effectively on the working parties, and holding the post against reinforcements, until the work of demolition was well-nigh accomplished. A daring attempt by a French serjeant, with the promise of a commission if successful, to enter the works along the seaside was defeated, and the gallant serjeant mortally wounded in the affray.

So the terrible work went on. The English fleet still held aloof. Most of the houses in the town were in ruins, and "opened to the heavens." Much of the bastions was actually demolished; and shot began to penetrate the merlons and gabions, and hit the defenders behind their faithless covering. Pigot had arranged a smart attack on the Black Town, to be carried out by Preston. But Preston could not carry it out; could not even get into the fort to confer upon it. Calliaud was retarded in the south, and a general assault was now deemed imminent. Well had Lally done his part, in spite of all difficulties. And well had his soldiers, at least, served him. But well too had the besieged fulfilled their task. No thought was among them—I do not say of yielding—but of ultimate failure. Hardly a murmur was heard, now that the timid, fidgety Nabob, and his troublesome followers, were out of the way. Cheering news too of Forde's victory had been received, and celebrated with the fire of the whole garrison, directed towards the French quarters. And they still hoped that the fleet would, ere long, turn their anxiety into triumph.

Lally held a council of war upon the advisability of storming forthwith, and himself declared in favour of that measure; but the officers pronounced against him. The breach was said to be practicable, but so much exposed to the enemy's fire as to be inaccessible. It was added spontaneously, that no good could come of prosecuting the attempt longer. Whichever opinion were correct, who does not pity and sympathize with poor Lally in this bitter moment? So near the crowning point of success, after such difficulties, so perseveringly overcome, after such exertions, so impossible to be renewed; to be warned off, by his own subordinates, from the desire of his eyes, the goal of his hard running! The end was indeed near. But not such an end as he had anticipated when he plunged head-long into the Anglo-

Indian war of extermination, or when he stood triumphant on the site of the demolished ramparts of Fort St David!

The end was near, and, as has so often happened both in India and elsewhere, when the operations of armies depend so much upon the movements of corresponding flotillas, there was a strong touch of the ludicrous in its abruptness. The English fleet was heard of, as approaching; was signalled, seen; and after an anxious night's anticipation of a last sudden attempt at escalade, the morrow's light broke upon the landing of the ships, and the pouring forth from the fort of a teeming joyous concourse, to inspect the deserted works of the vanished foe. Not only hopeless of success, but fearful for themselves, they had decamped during the night, in too great haste to burn (as Lally had threatened), the Black Town, or even to remove their own sick; so badly provided with beasts of transport, as to allow upwards of fifty cannon, and ammunition in abundance, to fall into the hands of the English. They marched away, Orme adds, in rags, and without provisions; but exacted the latter, as they went, by force.

The following details, supplied by the same able and careful author, will give an exact idea of the activity of the operations, and the crucial character of the struggle, with reference to the general fortunes of the war:—

"The fort fired during the siege 26,554 rounds from their cannon, 7502 shells from their mortars, and threw 1990 hand grenades; the musketry expended 200,000 cartridges. In these services were used 1768 barrels of gunpowder. Thirty pieces of cannon and five mortars had been dismounted on the works. There remained in the fort, artillery sufficient for another siege, with 30,767 cannon balls, but only 481 shells, and 668 barrels of gunpowder." As many of the enemy's cannon balls were found "in and around the works, or in the native town," as the garrison had expended. The enemy consumed all the shells of the two first rates in the stores of Pondicherry, and threw of all sorts 8000, of which by far the greatest number were directed against the buildings.

"Of the European officers, one major, Polier, two captains, six lieutenants, and four ensigns, were killed; one captain and one lieutenant died of sickness; 14 other officers were wounded, of whom some dangerously; and four were taken prisoners; in all 33. Of rank and file in the battalions of Europeans, and of the men belonging to the artillery, 198 were killed, 52 died in the hospital, 20 deserted, 122 were taken prisoners, and 167 wounded; in all 559; but many of the wounded recovered. Of the Lascars, who were natives assisting in the artillery, 9 were killed, and 15 wounded. Of the Sepoys, including officers, 105 were killed, 217 wounded, and 440 deserted. The loss in Europeans was more than reinstated by the troops brought in the ships."

The activity and judgment of the Governor were conspicuous throughout. Provisions had been abundantly laid up, and were regularly and methodically distributed by the well-trained civil officials. In every department, in fact, of the service, "all was emulation."

"All however acknowledged that the enemy, in proportion to their numbers, compared with the strength of the garrison and works, had pushed the attack with unremitting perseverance and endeavour, and the enemy equally respected the science and steadiness of the defence."

Orme then mentions the Company's officers who served zealously under "their preceptor in the siege," the veteran Lawrence; and adds the interesting fact that this was the first siege, whether offensive or defensive, in which Mr Call, the chief engineer, to whose journal and plans the historian was probably much indebted, had served. "Captain Hislop, who arrived with a company of the king's artillerymen, at the same time as Aldercron's regiment, was the senior officer in this branch; he had served in Bergen-op-Zoom. The Company's artillery, which furnished all the cannon and ammunition, was commanded by Captain Robert Barker; even the enemy acknowledged that the promptitude and execution of the fire from the fort was superior to their own: whatever guns or mortars were disabled on the defences, were immediately replaced by others prepared in store."

"Thus," he adds in conclusion, "every officer of distinction on the establishment of Coromandel was employed in the defence of Madras, excepting Captain Joseph Smith," who was in command at Trichinopoly.

The statistics on the French side are less precise. Orme estimates their force, on its advance from Conjeveram, at 2700 firelocks; and an intercepted letter of Lally's, towards the close of the siege, states that he had still 2000 Europeans; but on the spot seemingly not more than 1000 Sepoys.

On the whole, though the failure of this great undertaking was far from ending the war, it is not too much to say that it was "the beginning of the end;" for henceforth Lally was practically on the defensive.

And the end came full soon. The last act of the drama in India, though a bloody afterpiece was to be performed in Europe, disclosed the fall of Pondicherry, and with it that of the political power of the French in the Peninsula. Pitt and Coote, English valour, good conduct and wealth, the indispensable and powerful co-operation of our fleet, on the one hand; and on the other, the ill success of the French arms in Europe and America, the consequent absence of their fleet from the scene of action in India, and the baleful predominance there of internal dissension, mismanagement, and corruption—proximately famine, had consummated the ruin of the once proud metropolis of Dupleix's contemplated empire.

Haughty and impracticable in his tone to the last, Lally surrendered; to experience (even after the victor had occupied the place, and had dropped a tear over the sad spectacle of his emaciated prisoners, and the fateful catastrophe of their wild but gallant general) renewed insults from his intractable and exasperated underlings; and to expiate, on a French scaffold, not surely his own alleged treachery to the interests of a country which he had served not wisely but too well, but the accumulated mass of evil connected with the old *régime* at home, and the settlement in India, and the unpardonable crime of having commanded where France, smarting under repeated blows in other parts of the world, had sustained a scandalous, total, and irretrievable overthrow.

And we, who were the gainers by his faults, and who have risen upon that overthrow to Imperial greatness in the East, should of all men most compassionate his failings, and condone them in the memory of his cruel death; and solemnly ask ourselves, How have *we* used, how are we henceforth disposed to use, those vast opportunities, how to fulfil that heavy responsibility, which his ill-starred but not altogether inglorious career in part tended to devolve upon us?

Free as we are from many difficulties which beset his path, and prepared his failure, it may not be amiss to remember, that he was still, in no small measure, his own destroyer. The precipitancy, the arrogant temper, the superciliousness, above all the want of sympathy alike with Europeans and natives, of the Hiberno-Gallic soldier are not without their moral for us.

The empire of India has never been won, could not have been won, by men animated by such a spirit. Baber and Acbar conquered, just because they were generally just, considerate, generous and genial, as well as firm and prompt to strike, when striking was inevitable. In his faults, as in the catastrophe of the *raj* which he undermined, Lally recalls not a little the Mahmood Toghlaks, and Auzungzibs, who again and again have shewn how warily the Indian warrior and ruler should pursue a track, which must ever peculiarly lie

"*— per ignes*
"*Suppositos cineri doloso.*"

TACTICAL AND GENERAL INSTRUCTIONS

FOR THE

I. R. NORTHEN ARMY, ISSUED IN MAY, 1866, BY THE FELDZEUGMEISTER CHEVALIER VON BENEDEK.

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BY MAJOR GOODENOUGH, R.A.

I. *Prussian mode of Fighting, and Rules for our own conduct.*

Prussian mode of Fighting.—The Prussian Infantry.

THE entire Prussian infantry is exercised in fighting in close and in open order. Hence every infantry detachment may be used for skirmishing. For this latter service, the so-called light infantry; jägers, sharpshooters, and fusiliers, as well as the third rank of the whole remaining infantry are specially destined and particularly exercised. It is nevertheless only in the jägers that particular care is bestowed on target practice.

The employment of jägers in action is sparing and special in its character, since they should be well placed under cover of accidents of ground so as to act by their steady and never failing fire. *All offensive action is forbidden them.*

The offensive action required from light troops is carried out by the fusiliers who perform the duties which with us are required of the jägers.

The *Zündnadelgewehr*, which is a breech-loader, forms the prevailing weapon of the infantry. In order to profit fully by the advantages it affords, a system of tactics has been framed in Prussia whose notable characteristics may be collected under the following heads :—*

(1) To provoke and keep the adversary engaged in a combat of musketry.

(2) When on the defensive, endeavour to cause the enemy to manœuvre on plain ground, when on the offensive to manœuvre oneself in broken ground.

(3) To fight in a deep order, yet so that when great and rapid results are to be attained, the broader front can be re-established at any moment.

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* *Vide* Verordunugen über den grösseren Truppenübungen. Berlin, 1861, *passim*.

(4) Never to attack on the front alone, but at the same time on one or both flanks.

The most weighty of these principles is the first, for it requires fire to be resorted to at every opportunity, and to be kept up as long as possible. This fire should at the commencement be developed with extreme economy and in an extended order, afterwards in the same order, but with the introduction of nearly all the supports, and lastly, the whole division in close order.

The most customary formation for such a sustained musketry combat is the *company column*, which consists of three subdivisions standing one behind the other, namely, the two subdivisions into which each company is divided, and the skirmishing subdivision formed from the third rank of these two.

Where one battalion is employed (consisting always of four companies), the company colums are generally so ordered that one stands in the first line, one in the second, and one in the third.

Disposition of an Infantry Brigade for action.—The attack with the Bayonet.

In the case of a brigade the first Line* stands in company columns, the second in battalion columns; in front of the first Line* is the so-called advanced Line in two lines and in a loose order.

Into this advanced Line either the skirmisher subdivisions† of the whole first Line or the entire fusilier battalion, namely, that of the second Line are generally drawn.

The advanced line begins the action, in the course of which it is constantly reinforced by more men from the rear. Less than one section (4–6 files) from each battalion should never be left in the second Line of the advanced Line of battle.

For the maintenance of the fire of the first Line, particularly before a bayonet attack, the divisions standing in close order in the second Line move up to the first and deliver volleys over the heads of the men engaged in the first Line who kneel or lie down. The two Lines move forward simultaneously to the bayonet attack, till the first reaches the chain of skirmishers, when it breaks into a quicker time whilst the second continues its advance at its previous pace. At a short distance from the enemy the two leading ranks of all columns of the first line bring their bayonets to the charge and attack the enemy at a run. When the attack is successful, all the leading subdivisions of the columns of attack of the first line deliver one or more volleys, after which the skirmisher subdivisions advance again to follow the enemy up. When the attack is repulsed, the first line half-cock their arms, face about, and retreat. If the attack has had no definite result, but has only brought on a standing musketry engagement, this must be nourished by the

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* *Treffen*, here rendered *line*, has no equivalent in English, unless *line* in a technical sense may be so considered.

† *Schützeuzüge;* these are subdivisions formed from the third rank of infantry companies and equal one-third of a company.

reinforced line of skirmishers, or in the exceptional absence of the skirmishing subdivisions the signal is immediately given for file firing, and the battalion deployed as quickly as possible. If the enemy is shaken or thrown into disorder by this fire, the first Line throws itself upon him in its then deployed order to overthrow him completely. Should there be no hope of this, or if the enemy makes dispositions for passing himself to the attack with the bayonet, the line must face about and re-form the column of attack whilst retiring under cover of the chain of skirmishers left behind in its rear. The retreat may be conducted simultaneously by both lines, or, the second line waits standing in deployed line till the repulsed first line has passed it, and then commences volley firing.

If these dispositions have effect, the skirmisher subdivisions of the second line move forward, and the bayonet attack follows in the manner before described.

On the defensive, a similar course of proceeding is followed as in the attack; but it depends upon circumstances whether a deployed order should be adopted earlier or later, or throughout, or whether the enemy should be encountered by an advance, or his attack awaited.

The Prussian infantryman it may be said, is in marching not able to accomplish anything extraordinary, in action he believes the *Zündnadelgewehr* irresistible, he is very particular in seeking cover for himself, and very difficult to be got out of it when called on himself to make a bayonet attack.

Cavalry.

The Prussian cavalry is like the Austrian, divided into heavy and light, but practically the latter has little difference from the former; want of aptitude for the minor operations of war generally, and for outpost duties in particular, appears as a result of this. On the other hand in Prussia of late years, there has been much manœuvring with great masses of cavalry, though the ability shown therein was small. Generally thick chains of skirmishers would skirmish too near the force with little practicable ability, though with great expenditure of the strength of the horses.

Its proper value was not assigned to the column formation, long lines were frequently and prematurely developed, or a closed mass formation in entire squadrons adopted; attacks were feebly carried out, and could be so soon perceived by the adversary that the effect of surprise was lost, at times also the force would remain before the attack standing under a hostile fire. In the Campaign of 1864, the conduct of the Prussian cavalry showed elaboration without energy.

Artillery.

The Prussian artillery is an arm distinguished by the excellence of its material and its high intelligence, but it is heavier than the Austrian.

On the field, however, it moves about a good deal and changes position too frequently. It is not at hand at the right time or in sufficient quantity, and generally enters into action too late and too sparingly, breaking off just at the time when its greatest usefulness should begin.

Rules for our own conduct.

These peculiarities of the Prussian army considered, the troops of the I. R. northern army will conform generally to the following instructions :—

(1) The rules prescribed by the Regulations are always to preserve their full validity, for an unshakeable confidence in their worth is in war, the best foundation of success.

(2) A blind rushing forward without knowledge of the enemy's position or of the distribution of his forces is just as inadmissible as a timorous feeling of the ground in various directions.

(3) The peculiarities of each of the arms of which the army consists must always be taken fully into account, and when more than one are combined to form a larger tactical unit, the bringing of each into action and at the right moment is the point never to be lost sight of. On the mutual, well-timed, and liberal support of the different arms depends the probability of the success of an enterprize.

(4) Inasmuch as the orders emanating from head-quarters are only applicable to certain circumstances as known just at the moment of their issue, and therefore can only point out the proper line of conduct generally, it rests with the commanding officer concerned to act not according to the letter only, but to the spirit of the order, and to give such particular rendering and development to the general directions received as circumstances demand at the moment of their execution. And this is to be accepted as an invariable principle, that every detached body of troops unless it receives some special instructions, should consider itself as in connexion with the troops on its flanks and rear; it is therefore its duty always to acquire and keep up a knowledge of everything that takes place concerning the troops in its neighbourhood; this and its own situation determine whether it should operate in any new direction, which, however, is enjoined when no enemy is in front, and the sound of cannon is heard elsewhere.

(5) Thick chains of skirmishers are always to be avoided. The skirmishers should not open fire till they have approached to 300 paces from the enemy's line of skirmishers.

At 300 paces distance from the skirmishers follows the first line usually in divisions, 300 paces behind these the second line in battalion columns or in masses. It is to be understood that these distances, which are calculated for open ground, may be diminished in broken or enclosed country.

(6) To become entangled in anything like a prolonged musketry combat is strenuously to be avoided; any necessary feeling of the way preparatory for more general action must be executed rapidly and energetically with few and good sharpshooters, some light cavalry, and the whole of the disposable artillery; such preliminaries to be followed at the right moment by a vigorous onset of infantry and cavalry in close order.

(7) If there be any point near the enemy's line of skirmishers from which our artillery could operate very effectually against him, its occupation by our guns should not take place until the hostile skirmishers have been driven back to 600 paces from the spot. In such a case the placing of the batteries will often be attended with small partial engagements in which when practicable all three arms should take part. For instance, one or two troops of cavalry at least will go forward with the battery, and at an appropriate distance will throw themselves *en débandade* (dispersed) on the enemy's skirmishers; whilst these form rallying squares the battery has time to move up and unlimber, and our skirmishers have the opportunity to push forward and fire into the squares at a very close and effective range.

(8) In order to meet the flanking movements which the Prussians so often prefer to employ, a sufficiently strong reserve must always be detailed with which one may according to circumstances either support the direct attack or take the flankers in flank. The direct attack should in the case of Prussian troops generally have a good result, for with their present weapons it is considered by them almost impracticable, and it must therefore always surprise them when carried out with vigour.

(9) Since the entire Prussian system of training aims at teaching the soldier to consider his principal strength as lying in his *Zündnadelgewehr;* since they have carried the abuse of the application of musketry fire so far as to instruct their troops at the exercises in peace time, to halt when close to the enemy, even when advancing to the attack, in order to deploy and deliver volleys, and so regard this as the surest means of annihilating him, or causing him to succumb—therefore our troops must be taught that the enemy's musketry fire is only really murderous when one offers oneself to him as an immovable mark at the best shooting distance, allowing him to aim and fire quickly, and thereby confirming him in the confidence in the weapon which has been instilled into him; and that to destroy this confidence and to reduce one's own losses to a *minimum*, there is nothing better than to endeavour without losing much time in a useless fire, to move on the enemy with a steady bearing for two or three hundred paces, and then to fall upon and overthrow him on his own ground. An energetic dash, yet coupled always with proper circumspection, will, against Prussian troops, always bring about success most rapidly and completely.

(10) In fighting in a close and broken country attack and defence will both be essentially facilitated by use of the cover available. In such circumstances the principal part falls to our infantry and light cavalry. The artillery will frequently have to move up to a short range in order to produce a good effect.

In this kind of ground, the proper field of action of the Prussian skirmisher whose bearing is purely defensive, the best opportunity is offered to our jägers and our light cavalry of exhibiting their peculiar capabilities for offence.

II. *Conduct of the Troops in some special circumstances with reference to the eventual Theatre of War.*

A short distance to the north of the mountain chain which separates Bohemia and Moravia from Lusatia and Silesia there commences a wide plain which reaches to the Baltic, and which, between the Vistula and the Elbe, as far as concerns the case in question, is intersected by numerous streams and occasional swamps and marshes.

A considerable portion of this plain is covered with forests, yet nevertheless it is traversed in all directions by numerous and good communications. The cultivation generally is of a superior kind. This configuration of ground permits the movement and employment of large masses of troops, at the same time that it presents, in many places, tracts where the extended order of fighting of infantry may be profitably applied.

With reference to the above characteristics of the country on which the northern army may eventually be called upon to act, I deem it pertinent to issue the following directions as a guide to the troops under certain circumstances :—

(*a*) *Infantry.*

Infantry will move as a rule, in intersected and covered country, in division masses or columns; but in open ground, where sudden attacks of cavalry are to be expected, in battalion masses, because battalion squares possess more power of resistance than division squares.

When a detachment of infantry is much exposed to the enemy's fire, and the enemy's battery has, so to speak, "got the range," a short movement in any direction often suffices to relieve it from fire for a time.

On the defensive, infantry should find cover for itself behind accidents of ground, or by lying down. The advantage of cover must also be not too lightly given up even on the offensive, and in an attack with the bayonet for example, the attacking column should advance covered as long as possible from the enemy's fire, even though the approach to the enemy be thereby delayed; only the last 100 paces are to be done at a run.

Similarly, the signal "to charge" should only be sounded immediately before the attack, lest the enemy observe our intentions and have time to make his counter dispositions.

(*b*) *Cavalry.*

The cavalry attached to *armée corps* is never to be subdivided by squadrons among the brigades, but must, on the contrary, be kept together. The commandant should watch keenly for the moment when he may interfere effectually in the combat, whether in order to cover his own infantry or artillery from the attacks of different arms, or when necessary to disengage them, or to precipitate himself on the enemy's infantry whenever it may by any means become disordered, &c.

These rules apply in a higher degree to the commandant of any larger body of cavalry, as a brigade or division.

As long as the cavalry remains inactive, its position should be covered as far as possible.

A cavalry detachment detailed as protection to a battery should place itself on its flank and rear under cover, and at such a distance only, that when necessary, it may be instantly at hand.

(c) *Batteries Attached to Brigades.*

These should be placed at the commencement of the engagement in favourable situations, and except in rare instances, should not be subdivided. The battery should change its position as seldom as possible, and only when absolutely necessary, for by so doing it relinquishes its advantage of firing at known ranges, and during its change of position it is at once powerless and defenceless.

When a brigade battery finds itself at the moment of a cavalry attack in a favourable position on the flank of the brigade, it should never leave this position (as is laid down also in the Regulations), for by so doing it would not only miss the favourable moment of materially damaging the enemy's cavalry, but would also run the risk of being surprised whilst on the move.

Should the supposed case actually occur, that is, should the battery placed on the flank of a brigade be surprised by an enemy's cavalry, limbers and ammunition wagons should be sent to the rear at the gallop while the detachments fire case shot as long as possible, and then take refuge under the bayonets of the nearest square of infantry, whither also the mounted commanders betake themselves; the men of the guns which are furthest off, who have not time for this, throw themselves under the gun carriages, in order to re-open fire the moment the hostile cavalry retires.

Horse artillery batteries must trust for their protection to the bravery of the cavalry, the able dispositions of its chief, and lastly, to the presence of mind and circumspection of the commandant of the battery.

General Rules for the Commencement of an Engagement.

Should the advanced guard of a brigade come in contact with the enemy and become engaged with him, the Brigadier should betake himself immediately to the advanced guard, in order to judge of the situation and make his plans. The principle should be observed that such engagements should be maintained by the troops of the advanced guard alone until the entire brigade has marched up to the scene of action. The battery of the brigade should however be brought to the front, and should open fire at once. Nothing is more prejudicial than the successive bringing forward of single battalions for the support of an engagement, since by so doing the perhaps weaker but better prepared enemy has the opportunity afforded him of beating us in detail. The history of war contains in its pages many a deplorable instance of this.

With a *corps d'armée* the same rule should be observed, its advanced guard maintaining any engagement which has been begun, until the whole of the *corps d'armée* has marched up. As the brigade battery should take

part in the engagement from the first, so in the case of a *corps d'armée* it is necessary rapidly to bring to the front and employ the corps reserve of artillery. The corps reserve of artillery is, in fact, not to be regarded as a reserve in the proper sense of the term, and this view of it is all the more to be condemned as erroneous since it is capable of leading to most disadvantageous consequences; the name merely denotes that part of the artillery of the corps the disposal of which is reserved exclusively to the commandant of the *corps d'armée*.

Any hesitation on this point might easily have for result that the engagement (the duration of which, since the great perfection given to fire-arms, is likely to be short), would be already decided to our disadvantage before the corps reserve of artillery could be brought into action.

In continuation, I publish also for general guidance as follows:—

When operations commence, *head-quarters* will *fix itself* in the front at the head of the main body, with a view to avoid all loss of time in the communication of orders and announcements. A similar rule will obtain for corps and brigade commands.

As the orders should always set forth *clearly* and precisely the object in view, so also every subordinate must strive not only to comprehend them quickly and in a straightforward manner without any hair-splitting, but also to carry them out without hesitation.

Where circumstances imperatively demand a departure from the orders received, the same is to be brought immediately to the knowledge of the head-quarter whence the orders emanated. In the case of all announcements and orders affecting the operations, not excepting those written in pencil—the *hour* of the despatch and of delivery should be noted.

The daily *reports of events* (*Vorfallenheits-rapport*) which contains the marching out strength, the positions of troops, the report of sick, the time for which the troops are provisioned, and any difficulties appertaining thereunto, with the remedies applied, &c., &c. should be despatched by *corps d'armée* or detachments which report direct to head-quarters, so as to arrive as a rule at head-quarters towards evening.

But when a detachment shifts position about mid-day or later, it sends off its report before moving off.

The brotherly feeling (*Kameradschaft*) which constitutes the cement of an army, demands that *mutual consideration* should govern the relations between all troops on all occasions, as well before the enemy, on the march, in camp, or in action, and I expect it from the *chevaleresque* spirit of commanders of troops that this should be observed rather too much than too little.

Whenever it is practicable "*mounted*" *officers* should remain mounted during an engagement.

Conversations of a *depressing tendency*, as well as the spreading of unfavourable intelligence, are never to be suffered.

All *private intercourse* on official subjects with agents of head-quarters is forbidden; if any one have propositions to make on matters of service they should be laid officially before the commander of the army (*Armée commandé*).

Carriages of all kinds may when in retreat only go at a walk.

Officers are to be thoroughly instructed that they are on all occasions, and therefore also in action, to consider themselves as the *leaders* of their detachments, and that they should not quit the places assigned them. Personal bravery is certainly a virtue, yet it loses none of its value in being manifested at the right time and place. A detachment which has lost all its officers (and this is usually the result of their exhibiting such blind impetuosity), is generally to be regarded as no longer fit for action. On every march of an independent detachment either to front or rear, the prescribed military precautions of safety are uniformly to be observed.

Camp guards when prescribed are always to be mounted, not too many of them, but these properly placed; it must also be looked to that they fulfil their proper duties.

Orderlies and officers employed at head-quarters, should when sent on messages, confine themselves strictly to the fulfilment of their orders, and should then return without delay and report the accomplishment of their errand. Should they not do this, but on the contrary take advantage of this opportunity to engage in action on their own account, they would by such unmilitary behaviour leave their superior in ignorance whether or not the order had been delivered, and was in the way of execution. It would result as a further consequence, that even in the case of a sufficiently numerous staff the superior officers would be left, if the engagement were a little protracted, entirely unattended.

Out-post duty is to be conducted with as few *vedettes* as possible, on the other hand the greatest attention is to be paid to the duties of patrols in general, and to those directed towards the front in particular.

Where cavalry is allotted to infantry outposts, they should not be detailed for the stationary duties, but should by preference be employed as patrols.

Every column marching independently should take with it one or more *guides*, even when marching on the great roads, and although it may be possessed of the best maps.

The *saving* of men and horses will always form a principal point for the attention of commanders even in action. Under this head is to be understood every alleviation which is compatible with strict discipline, as for example:—

(*a*) More particularly in hot weather, loosening of neck cloths and stocks, partial unbuttoning of coats and cloaks, &c. &c.

(*b*) During pauses in action the troops should refresh themselves with the provisions brought with them, yet without leaving the ranks; smoking is to be permitted unconditionally.

(*c*) Infantry may as long as they are not themselves firing, lie down without breaking the ranks; they are often thereby withdrawn out of sight and out of fire.

(*d*) Cavalry and artillery drivers may dismount, as long as they are not themselves under fire.

When these relaxations are ordered by command from higher authority, they appear merely as proofs of the consideration of the superior in command, and it will occur to no one to see in them any intermission of discipline.

The members of the bands are not to be considered merely as musicians for service in peace, they are no less than soldiers whose function before the enemy is to cheer and encourage their comrades; they are therefore not to be sent to the rear at the beginning of an engagement, their place in action is with the main body of their corps; as they belong to the corps, so as brave soldiers they should stand with it in action by the side of their combatant comrades, helping them to win success, and ready to conquer or fall with them; as they share the dangers so they will also share the glory of their corps.

When the army is marching in several parallel columns, and one of them becomes engaged whilst the others have no enemy opposed to them, then the *thunder of the cannon* gives the direction which the detached corps ought to follow.

Officers of the general staff, and adjutants hasten to the front to take orders and convey them to the advancing troops. This principle is valid also for smaller detachments in a similar case who have no enemy opposed to them, and are not tied by precise orders.

* * * * *

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IV.—*Conduct of Escort for Guns.*

The recently attained great mobility and power of manœuvre of the artillery, coupled with the destructive power of its action, raises it at once to the highest rank as a weapon for offence and for defence, and enables it to take part with the other two arms in nearly all the operations of war; to open general actions, and through the almost irresistible effect it has recently acquired, to decide them.

In spite of these extraordinary advantages this arm is often, owing to circumstances of ground, or when in movement, quite incapable of offence, and in hand-to-hand fight with infantry or cavalry is equally deprived of defensive power. Tactical independence is wanting to it, for which reason it almost always needs the protection of the other arms.

In order therefore to put a battery in a condition to be able to respond to the calls made upon it, it must not only be protected from the immediate attempts of the enemy through the mutual support afforded by the mode of placing the troops in order of battle, but a suitable permanent escort should be given it to protect men and horses from all annoyance from individual skirmishers, from troopers, or from detachments, as well also as from surprises in the gun park.

The battery escort of a battery attached to infantry should consist of four under officers and twenty-four men (as far as possible good skirmishers) under an officer. In the case of a battery attached to cavalry, or generally with horse artillery batteries, the escort should consist of a detachment of the strength of half a squadron.

This escort will always be accorded to the battery before the enemy, and during the execution of field manœuvres in peace, but in the case of purely tactical exercises only so far as may be necessary to make the men thoroughly conversant with their duties.

Should the battery however be engaged in some more extensive and independent enterprise, its commandant should look to the commander of the

whole force to furnish him with a stronger detachment commensurate with the wants of the situation.

The originally established escort remains with the battery in all cases.

When the batteries serving with the reserve are employed together, a common escort will be given them, generally of light cavalry, its strength being according to the circumstances.

Upon the escort devolves in camp and cantonments, the guard of the guns, the rendering assistance in case of obstacles on the march; finally, the filling the easier duties at the gun when casualties occur during an engagement.

The commander of the escort is in every case to be subordinate to the commandant of the battery.

When before the enemy the permanent escort should always remain united with the battery. Casualties in its prescribed strength should be at once made good, and it should not be relieved except in case of necessity.

On the March.

In case that a battery is required to march any considerable distance in the enemy's neighbourhood with only its permanent or even with a reinforced escort, its march is to be protected by an advanced, flanking, and rear guard.

The main body of the escort should move at a convenient distance from the battery, in its front, or on the flank on the side threatened.

On a march where no danger is to be apprehended, half the escort should in an advance, march in front, and half in rear of the last gun of the battery.

On a retreat, a part of the escort marches in front of the first gun and behind the last of the ammunition wagons, the other larger section with the commander of the escort marches behind the last gun.

Should the battery meet with broken intersected ground, a proportion of the main body should be extended in a chain of skirmishers to search it.

In passing defiles, their issue should be previously occupied, and the ground beyond searched; similarly, heights in front or on the flanks are to be reconnoitred and made safe.

In an encounter with the enemy on the march, the fire of the skirmishers should be employed, or an assault with the bayonet, or a determined attack be made, in order to give the battery opportunity either to take position for action or to retire.

In Action.

In a direct advance in action the commander of the escort is in front, in retiring, and also on the retreat in presence of the enemy, he should be with the part of his detachment which follows the battery.

During the movements of an engagement the escort should remain on the threatened flank; in advance, on the flank and front; in retreat, in flank and rear of the battery. When stationary, in action, the escort should place itself on the flank and in rear of the battery on its more exposed flank, and covered as much as possible.

The escort should be at no greater distance than will allow it in case of a hostile attack, whether of cavalry or infantry, to come up in proper time to the defence of the battery.

When the battery is exposed on both flanks the escort should be divided and posted according to the circumstances of the danger.

As a matter of course the escort should not post itself in rear of the battery since it would there catch all the enemy's fire.

In intersected ground the escort should maintain small posts of observation on the flanks of the battery, even when our own troops are on both flanks, in order to keep up a better knowledge of the course of the action.

When a battery in position is attacked by the enemy's infantry or cavalry, it should defend itself by its own fire up to the last moment, since the duty of the escort is then only to protect its flanks.

Should the enemy however succeed in penetrating the front of the battery, the escort should precipitate itself resolutely upon him without regarding his strength.

The defeated enemy is not to be followed up by the escort, but by the fire of case shot.

If the battery be divided, the escort should be so also, according to circumstances.

The commander should accompany the detachment which first comes into action, or that on which the more important service may be expected to devolve.

The above directions serve also for the escorts of larger bodies of artillery, which are to be brought together, placed under the senior officer, and should conduct themselves as prescribed for the escort of single batteries.

Should it happen in the case of a thus enlarged escort that its commander should be senior in rank to the commandant of the battery, the latter continues to be nevertheless by virtue of his office the commandant of the column, and it devolves on him only to make dispositions and give orders.

MOUNTAIN TRAIN FORMED FOR SERVICE

IN

ABYSSINIA.*

BY CAPTAIN C. O. BROWNE, R.A.

CAPTAIN INSTRUCTOR, ROYAL LABORATORY.

This train has the following properties:—

(1) The equipment is light, and is portable under difficult circumstances.

(2) The guns are powerful and accurate for their weight, and are available for vertical as well as horizontal fire.

(3) The battery can if required be moved with speed over level ground by draught, mounting men on mules, &c.

Exclusive of a reserve, the details of which are not laid down, the whole equipment is carried on 38 mules as follows:—

6 guns	6	mules.
6 carriages	6	"
360 rounds of ammunition	18	"
120 rockets and 2 tubes	6	"
1 forge	1	"
Miscellaneous stores and material	1	"
Total ...	38	mules.

There are thus six different kinds of loads.

LOAD 1. *Vide* sketch.

	lbs.	oz.
Gun, small stores, elevating screw, shafts, sponge and rammers, wad hook, &c.	199	4
Mountain artillery saddle with "wantie" and bridle	63	0
Total	262	4

* The details of packing, &c. in this paper are taken from Captain Gordon's "Equipment of Stores" for mountain battery. The particulars as to the guns and carriages are chiefly obtained from Col. Wray's Memorandum on 7-pr. Mountain Equipment.

LOAD 2. *Vide* sketch.

	lbs.	oz.
Carriage, traces, &c.	194	12
Mountain artillery saddle with "wantie" and bridle, &c., and with axletree arms	65	0
Total	259	12

LOAD 3. Ammunition.—*Vide* sketch.

8 common shells, 8 shrapnel shells filled and plugged, 4 case shot, 20 cartridges (6 oz.) in paper covers, fuzes, &c.	219	5
Otago saddle, surcingle and bridle	39	0
Total	258	5

LOAD 4. *Vide* sketch.

2 panniers containing 10 rockets each	233	12
Otago pack saddle, surcingle and bridle	39	0
Total	272	12
2 mules will also have rocket machine	24	5
Total	297	1

This load being too heavy it is proposed to dispense with two or even four rockets on each of these two mules.

LOAD 5.

Forge, hammers, &c.	240	13
Otago saddle, surcingle and bridle	39	0
Total	279	13

LOAD 6. Miscellaneous Stores.—*Vide* sketch.

Near Box.—Smiths and armourers, collar makers and wheelers tools and material	79	0
Off Box.—Hatchets, saws, lashing ropes, tools and material	80	0
Centre Box.—Pickaxes, spare axletree, helve, shovel and intrenching tools	40	0
Cover	5	0
Otago saddle	39	0
Total	243	0

The above being a general outline of a battery, the material may be noticed individually.

Gun. The gun is of Firth's steel.

Average weight	1 cwt. 1 qr. 6 lbs.
Preponderance	5 lbs.
Length of bore	24 inches.
Total length	29 "
Calibre	3 "

The rifling is on the French system, three angular grooves, uniform twist of one in 20 calibres. Grooves ·6″ wide, ·06″ deep.

The breech sight is a rectangular steel bar fixed to the right side of the breech, inclined at 3° to allow of the shot throwing to the right.

Muzzle sight is a hog-backed leaf sight fixed on right side of muzzle.

The following table shews elevation and times of flight corresponding to certain ranges:—

Range.	Elevation.	Time of flight.	Range.	Elevation.	Time of flight.
yds.	° ″	sec.	yds.	° ″	sec.
100	0 26	0·4	1100	6 41	5·4
200	0 50	0·9	1200	7 30	6·0
300	1 19	1·3	1300	8 21	6·6
400	1 54	1·8	1400	9 15	7·2
500	2 29	2·3	1500	10 14	7·9
600	3 5	2·8	1600	11 15	8·6
700	3 44	3·3	1700	12 21	9·3
800	4 25	3·8	1800	13 30	10·0
900	5 9	4·3	1900	14 44	10·7
1000	5 54	4·9	2000	16 0	11·4

Obtained with a charge of 6 oz. F. G. powder and common shell filled.

Carriage. Steel brackets, iron axletree, teak bed.

Length off wheels, 4 ft. $\frac{1}{2}$ in.
Length on wheels, 4 ft. 10 in.
Angle of trail with ground, $21\frac{1}{2}°$.
Height to centre of gun, 1 ft. $10\frac{1}{4}$ in.

Wheels. Nave, mahogany felloes, spokes pedook.

Diameter	2 ft. 6 in.
Track	2 " 2 "
Weight of carriage and wheels	192 lbs. 12 oz.

The carriages are designed for horizontal or vertical fire. In the former case the tangent scale gives up to 10° elevation. The maximum depression possible is 20°.

The recoil with the wheels free to move on grass is about 22 feet, and with the wheels attached to the trail eye by trail ropes and toggles, 10 feet.

The wheels may be removed and the gun fired on its carriage on the ground with elevation up to 14°.

Vertical firing.

For this the elevating screw is removed and the gun first laid direct on the object and then the breech lowered into a hollow in the centre of the carriage giving an elevation of 34° (the carriage having its wheels on).

Adaption to Draught.—Vide centre of sketch.

With each gun is carried a breech lift (which is used under the breech in lifting it off the mule), and one shaft in two lengths joined, when required by a socket (like a tent pole) and a pin.

For draught, two guns are made to act the part of gun and limber.

The first gun forms a limber, the two complete shafts being passed through sockets at the extreme end of the breech lift and a ring fixed on the end of each shaft like that of the ordinary service off shaft is made to take the place of the washer on the axletree arm end. The front ends of shafts rest in tugs fixed on the side pieces of the saddle.

The trail eye rests on the centre of the breech lift and is lashed to it by the trail ropes.

The traces attach the breast harness to two links and washers on the axletree arms inside the wheels (one is visible through spokes of wheels on centre mule at bottom of sketch), the traces are kept from hanging too low by being passed through loops on the breeching and rings on the breech lift.

The second gun is limbered up to the first by means of a strap in the trail eye which is buckled through the breast bolt eye of the first gun.

It is considered that a light field battery might be thus formed, the nine mules whose loads have been removed becoming available for mounting men; the Otago saddle *when properly made* is suitable for riding.

Ammunition.

Carried on mules. Projectiles filled, common shell, Boxer's shrapnel shell, case shot. Cartridges filled, 6 oz.; fuzes, time, Boxer's 10 seconds, 5 seconds tubes.

In reserve,—double shells; cartridges filled; fuzes, time, Boxer's 15 seconds.

Common shell. This as well as the shrapnel and double shells is fitted with 6 zinc studs (2 to each groove) attached by undercutting. It is lined with red lacquer. Fuze hole, "common gauge."

Weight, empty	7 lbs.	Total 7 lbs. 7 oz.
Bursting charge, L.G. powder ...	7 oz.	
Length of shell	6·8 inches.	

As has been said, these shells are carried filled and plugged, marked "filled" in red paint.

Shrapnel shells, Boxer. Contains balls of lead and antimony packed in rosin on a perforated diaphragm plate of wrought-iron beneath which is a powder chamber taking a bursting charge of 8 drs. shell F. G. powder.

The shell is weakened by lines of least resistance, the head is filled with wood.

Weight filled, with primer, 7 lbs. 8 oz. 2 dr.
Length, 5·5 inches.

They are issued filled and with a primer screwed into the passage down the axis of the shell to the bursting charge. They have been found very effective up to 600 yards.

Case Shot. Consists of a tin case with tin and wrought-iron bottom and a lining of three thin wrought-iron plates running longitudinally like the staves of a barrel. Inside are thirty-six one ounce iron balls packed in coal dust.

Weight, 5 lb. 3 oz. 12 drs.
Length, 5 inches.

It gives good effect at 200 yards range, but it has been suggested to substitute small balls of mixed metal as more effective at very short ranges. Indeed, on abrupt and rocky ground and across ravines, case shot, many of which graze very near the muzzle and so depend for their effect almost wholly on ricochet, are of avail only at the shortest ranges.

Cartridges, are white serge hooped with blue braid and choked with worsted, containing 6 oz. of F. G. powder; they are packed in paper bags, twenty are carried in centre box along mules backs. *Vide* centre mule bottom of sketch.

Fuzes.

Fuze 10-*seconds M.L.R.O. Boxer special* resembles Boxer's M.L.O. 9-seconds fuze,* but differs in being of the common gauge and having a calico strip (without a metal one) to cover the quickmatch laid round head in groove, which being larger in quantity causes it to bulge in a projecting ring, the quickmatch is divided across to stick out on uncapping and ignite more readily.

Fuze 5-*seconds M. L. R. O. Boxer special,* resembles the above, but is driven with mealed powder, and so burns only five seconds, the divisions giving half-tenths. It is painted red (which colour in a fuze signifies mealed powder), it is specially designed for the shrapnel shell.

N.B.—It may here be noticed that the marking of the fuze appears false, that is, the divisions marked half-tenths are not real half-tenths of inches, but at such a distance apart as corresponds to half a tenth of an inch of ordinary fuze composition, so that any one taking up either of the above fuzes, or the 15-seconds fuze given below, and setting it to some given length, will read off the figure given and bore it correctly, irrespective of which fuze it may be.

Tubes, friction, copper, differ from the copper friction tubes of the service only in being 2·1″ long.

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* Vide p. 426.

Ammunition in Reserve.

Double shell, lined like common with red lacquer.

Weight, empty	13 lbs. 7 oz.	Total 14 lbs. 7 oz.
Bursting charge	1 lb. L.G. powder.	
Length	13·2 inches.	

These shells in spite of their great length, low velocity, and high angle of elevation at vertical fire, keep point first. Two burst flew into 47 and 48 pieces.

Cartridges. Red shalloon, hooped with one hoop of blue worsted braid choked with worsted containing a charge of 3 oz. F.G. powder in paper covers.

They accompany the double shell, and are intended to be reduced as required.

Fuzes, 15-seconds, painted like the 10 seconds and the M.L.O. fuzes, and has the same fine grain powder channels; it is driven with slow composition burning at the rate of 1 inch in 7½ seconds, each hole reads for 1½ tenths fuze composition, and is so marked.

N.B.—The fuze hole of the above shells being the common gauge tapped throughout, the following fuzes might be tried on an emergency :—

Time. Boxer's common, diaphragm, and small mortar.

It is not certain how they would act, but they might be tried.

Percussion fuzes. It has been found that the time fuzes supplied with the shells act as percussion fuzes, being driven in on striking, and no percussion fuzes have been sent. If required, Pettman's land service fuze might be tried with the common and double shell, and possibly the general service would be found to act also, as it screws in for the greater part of its length.

The boxes containing the ammunition are cedar, covered with canvas, the strong threads of the canvas running across the fibres of the wood so that the former and latter should naturally not tear and split in the same direction.

These boxes are made small enough to carry by hand if necessary, the four on the mules sides each contain two common shell, two shrapnel shell, and one case shot. They are placed as shewn in sketch.

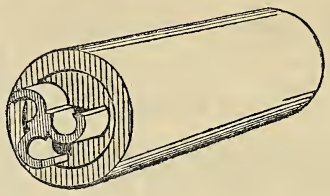
Rockets, 6-pr. Hales'.

Weight	8 lbs. 7 oz.
Length	16·2 inches.

These rockets, like the other calibres of Hales' rockets, are fired without sticks, being kept point first in flight by rotation given on the turbine principle, that is, by the pressure of gas escaping from the vents in the

base against three curved shields, each placed in the same relative position to one of the three vents, *vide* Fig. 1.

Fig. 1.



The object being to allow the gas to escape directly to the rear and so give its *full available force* to propel the rocket, the rotation being given by the gas in its further expansion after its escape from the rocket's base, which presses on the three shields. This method of utilizing work previously wasted being somewhat analogous to the expansive working of a steam engine.

N.B.—The above explanation is pretty, but it is not the exact truth to say that the force employed is not available for propulsion.

The bore of each vent and the inside of its shield is part of a cone whose apex is to the rear, this form being taken from the "turbine" water wheel, which is employed to obtain a very high velocity of rotation from water passing through similar orifices and striking the inclined surfaces; here there is no expansion, an extraordinary speed of rotation being given by the slight obstruction of the passage of the water. In the rocket the expansion of the gas increases the pressure enormously, but the question of retardation still holds good, and must necessitate a stronger, heavier rocket case in which a smaller vent might have been made, and any pressure on the rocket which gives the rotation might have been employed to give propulsion. This construction of Hale's gives good results.

Machine. The rocket machine is a small one shewn in centre of sketch, length of tube 3 ft. 5 in., it requires little explanation.

The tube hinges at the rear, and is fixed by a screw to such part of the vertical bar in front as gives the required elevation by the tangent scale.

Above 7° good results are obtained.

A friction tube resembling the one for the gun, but made up to fit the rocket's vent by paper wound round it, is used with a lanyard to fire the rocket with a quick pull, a slow one being liable to capsize the machine.

Saddles.

This subject is one requiring special experience to handle properly, a very few remarks are offered. It seems desirable,

(1) That the saddle should rest fairly and evenly on the parts of the ribs which are most nearly horizontal, that is, the parts near the spine.

(2) That the centre of gravity of the load should be as low as is convenient, and that the load should project as little to each side as possible.

(3) That the girthing and lashing of load should be simple, strong, and easily tightened.

The last pattern of general service pack saddle has been complained of on account of the bearing of the side bars, the transverse section resembling a V too closely, and the saddle having a tendency to squeeze the mule into the V. *Vide* Fig. 2, shaded portion.

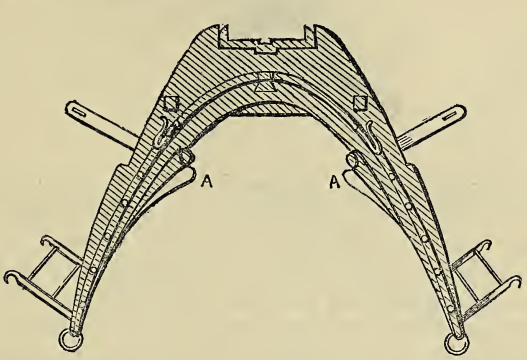


Fig. 2.

In the present pattern, by adopting the form shewn by the unshaded part, a bearing is obtained with surfaces forming an obtuse angle, and therefore with little tendency to rub and wedge the horse. The back bone is of course quite clear.

Two patterns of saddles are supplied :—

(1) The mountain artillery saddle for gun and carriage, with tree of walnut, iron bound, and with separate pannels attached to side bars having a slit inside each pannel to admit the hand to move and adjust the stuffing if necessary. Walnut wood is very light, well suited to stand climate, but easily split.

Small steel axletree arms are attached to the saddles which carry the carriage, to take the wheels. The general form of this saddle may be seen on sketch, and Fig. 2.

The gun is carried across the mule, a gun so placed appears at first dangerous when moving on a narrow way close along the face of a cliff; this gun however is short enough to form the narrowest load in the battery, a mule's back being curved behind the wither, the weight can be brought lower down and closer in to his back, laid across it, than along it, and the higher the centre of gravity of the load, the longer the lever with which it acts to upset the mule if thrown at all out of its position of "unstable equilibrium," and so also the more unequal the strain on him in climbing and descending steep places.

The carriage is placed longitudinally, *vide* sketch, this is perhaps the most awkward load in the battery, owing to the oscillation of the trail and the tendency to work slightly loose.

The load on the mountain artillery saddle is secured by a "wantie" of web and cord.

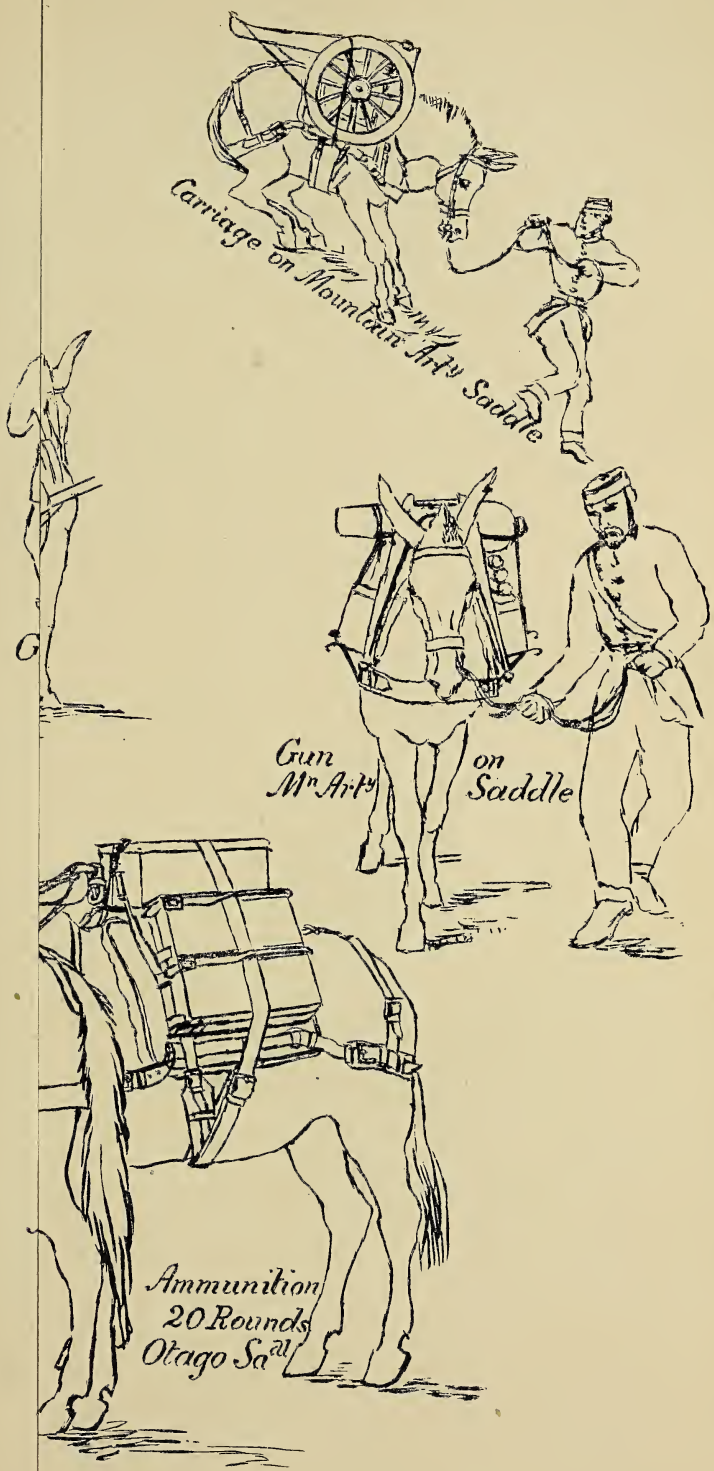
The Otago saddle brought to notice by Deputy Commissariat General Bailey, C.B., who knew it by experience in New Zealand, is supplied to carry ammunition, and for general service.

The tree consists merely of small wrought-iron fore arch and hind fork fixed to side bars and covered with leather, which if tightly stretched forms a good seat for riding when required, stirrups being attached.

Fig. 3.

A wrought-iron cradle is also proposed by Mr Bailey, and is to be tried to fix on to the Otago saddle and enable it to take the gun or carriage as above; this seems suited to the scheme of draught referred to, for the mules that become available for other purposes on putting the guns in draught are those that have been carrying the guns and carriages. The load on the Otago saddle is secured by a surcingle instead of a "wantie."

The whole of the girths are so placed that they can be readily tightened, which is a necessity of frequent occurrence with mules.


Carriage on Mountain Artᵧ Saddle
Gun
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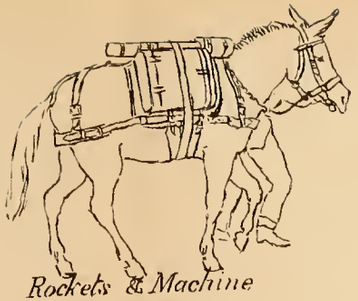
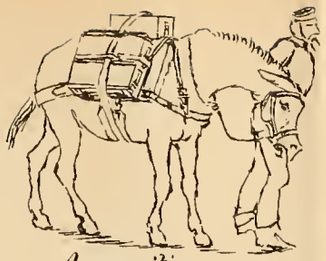
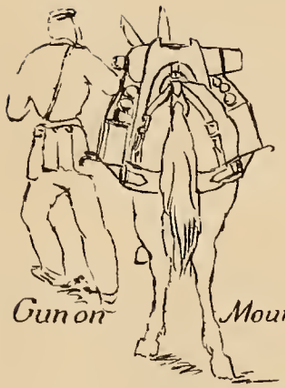
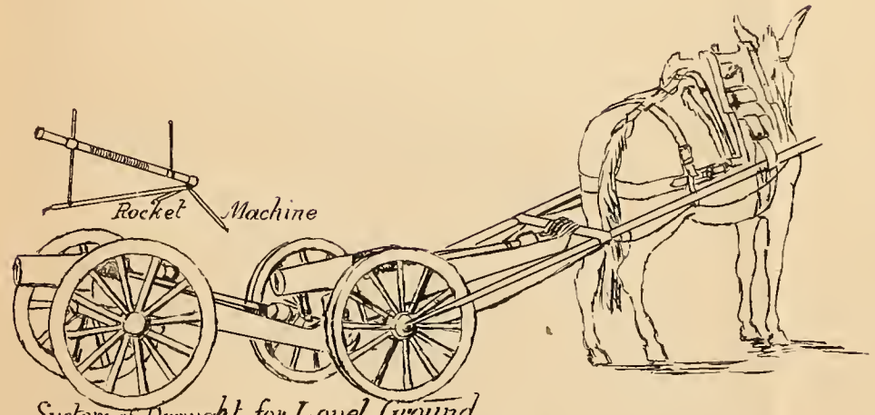
on
Saddle
Ammunition
20 Rounds
Otago Saᵈˡ

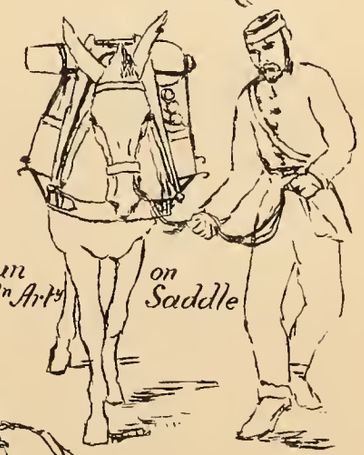


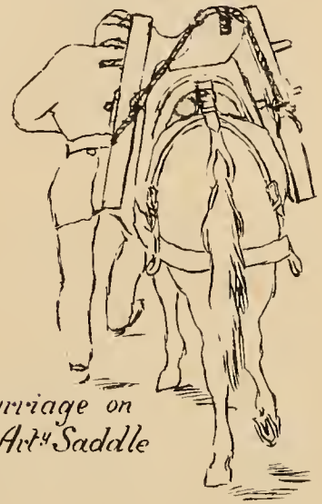


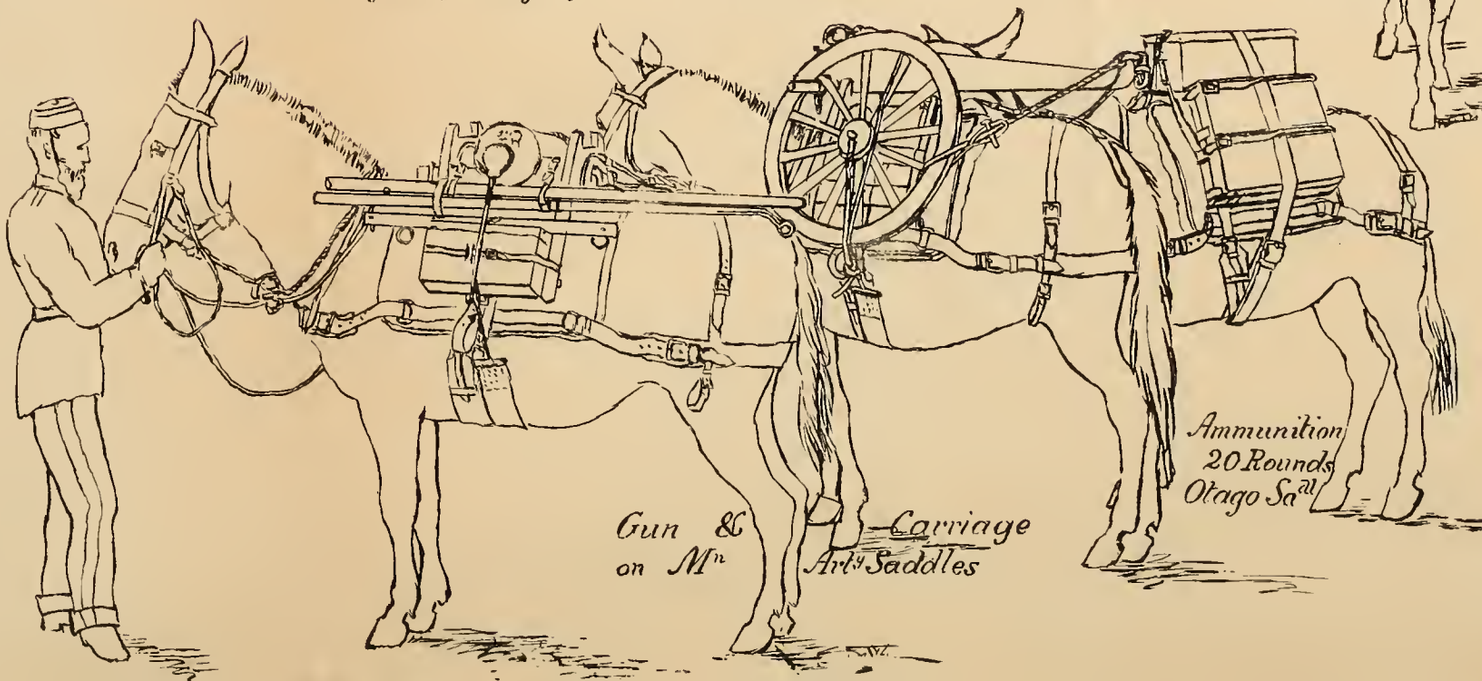




System of Draught for Level Ground







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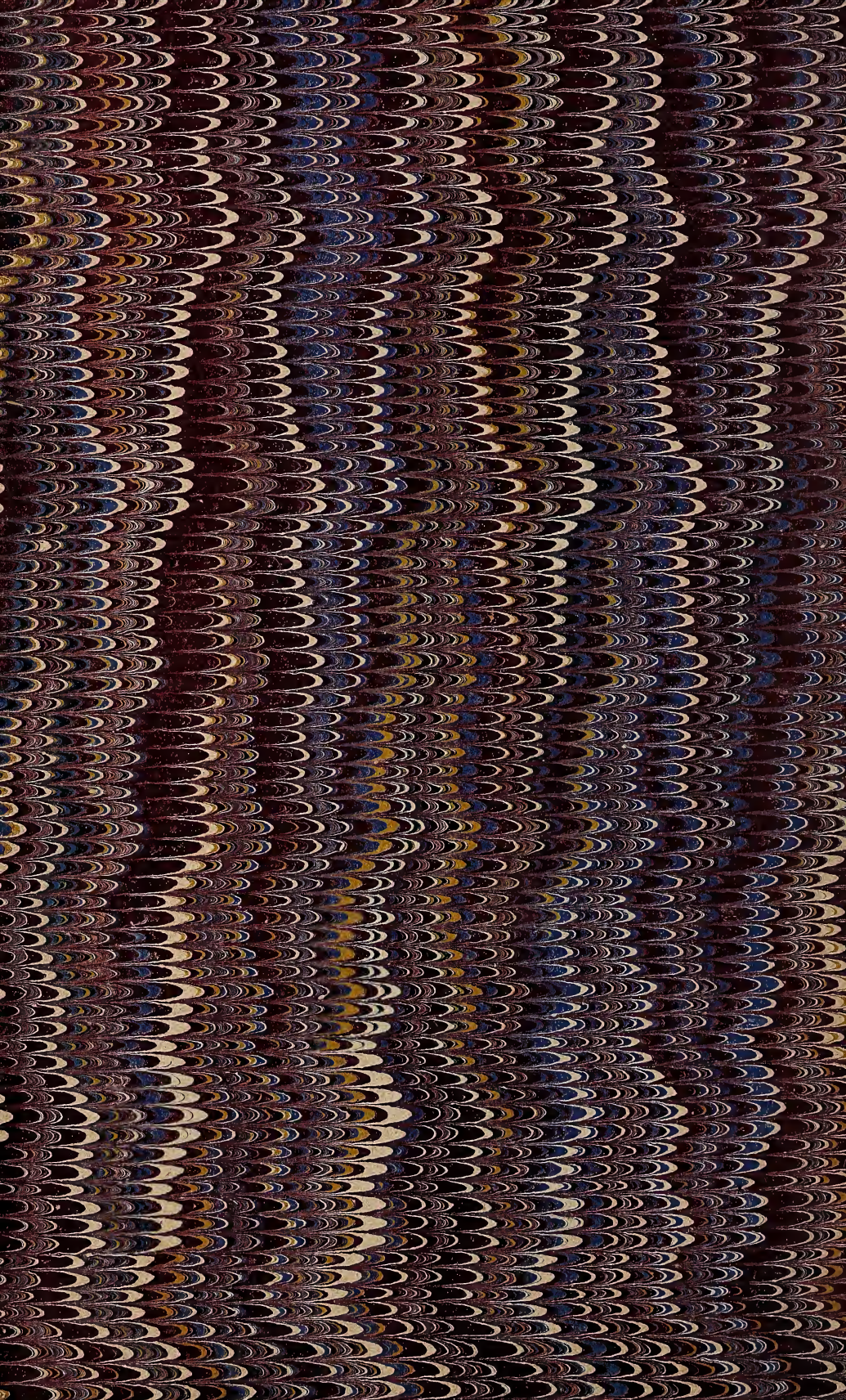

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